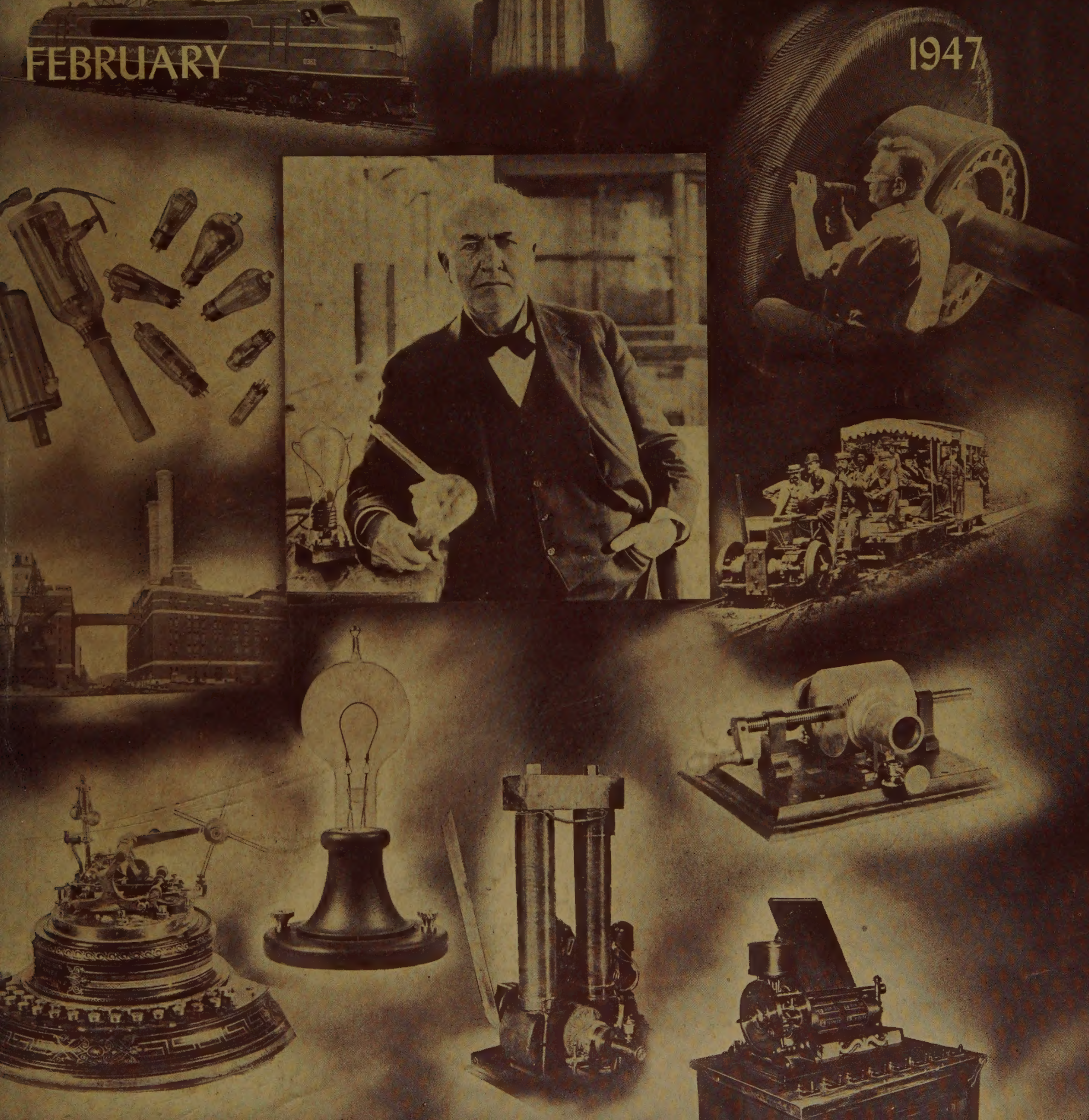
IN TWO SECTIONS—SECTION 1



# ELECTRICAL ENGINEERING

FEBRUARY 1947



# Thomas A Edison Inventor

THOMAS ALVA EDISON, probably the greatest inventor that America has produced, was born at Milan, Ohio, on February 11, 1847.

According to family records, the paternal ancestor of the Edisons landed in New Jersey, from Holland, about the year 1730. The family on Edison's mother's side, the Elliots, was of Scotch-English origin and settled in New England prior to 1700. After moving several times because of political views, Edison's parents finally settled at Milan, Ohio. Here three children were born: William Pitt, Tannie, and Thomas Alva. All three children showed ability, but that of the two eldest was of an artistic and literary character.

When young Edison was seven years old, his family moved from Milan to Port Huron, Mich. The boy was good-natured, courageous, and endowed with curiosity insatiable. He used to express surprise that the grown-up people around him were unable to answer his numerous questions. He spent three months at the Port Huron public school, that being all the formal schooling he ever had. As a scholar, he does not appear to have made a success. His mind was keen enough, but did not follow the grooves of school learning. His mother, who had been a teacher and understood him, attended to his education herself. Under her guidance he became proficient in reading and writing. Arithmetic he never cared for. He soon revealed a great thirst for experimenting, and especially for chemical experimenting. He spent his pocket money on inexpensive chemicals, and his spare time in the family cellar, trying out their properties—to see if what the book said was true. Throughout his life, Edison never accepted a textbook statement as final, until it had been tried out.

When the boy was 11 years old, he commenced his first venture in business by taking family garden produce to market in Port Huron in a little horse wagon with the aid of another lad. At 12 years of age he applied for and secured a concession from the Grand Trunk Railroad to sell newspapers on the trains between Port Huron and Detroit. In this way he was able to gain more pocket money for chemicals and experiments. He not only kept up this newsboy work on the trains, but also extended it by employing other boys as assistants on other trains and opening two small stores in Port Huron, each operated by a boy companion. Later he transferred part of his stock of chemicals from the family cellar to the baggage car of the train on which he worked. He was very popular with the trainmen, who knew him as "Al". About this time, he purchased in Detroit a small hand-printing press, with forms and type. He persuaded the train conductor to let him mount this in the baggage car.

It was in 1862, when Edison was 15 years old, carrying regularly an 18 hour workday, that an accident occurred which left him with a permanent deafness in both ears. A stick of phosphorus jolted to the floor and started a fire in the car that took all the efforts of Edison and the train crew to subdue. The conductor was so angered that he soundly boxed young Thomas' ears. When the train stopped, all the stock of the laboratory and printing press was thrown out on the station platform, to his great distress. In Edison's opinion, the injury to his hearing, that may have been caused by the cuffing, was intensified later, when a friendly trainman tried to help him climb on a baggage car, by pulling on his ears.

The slight deafness which came on after these events became permanent and gradually increased in later years. A man of lesser caliber might well have become morose by this infirmity; but it certainly did not have that effect upon Edison.

**The title signature is a reproduction of that which Edison attached to the AIEE prospectus issued in April 1884. "Biographical Memoirs of Thomas Alva Edison", which appears here in digest form, was presented to the National Academy of Sciences by Arthur E. Kennelly at the autumn meeting, 1932. Doctor Kennelly was a past president of the Institute (1898–1900), Honorary Member (1933), and Edison Medalist (1933). He was closely associated with Edison, being his principal assistant at one time. He died June 18, 1939.**

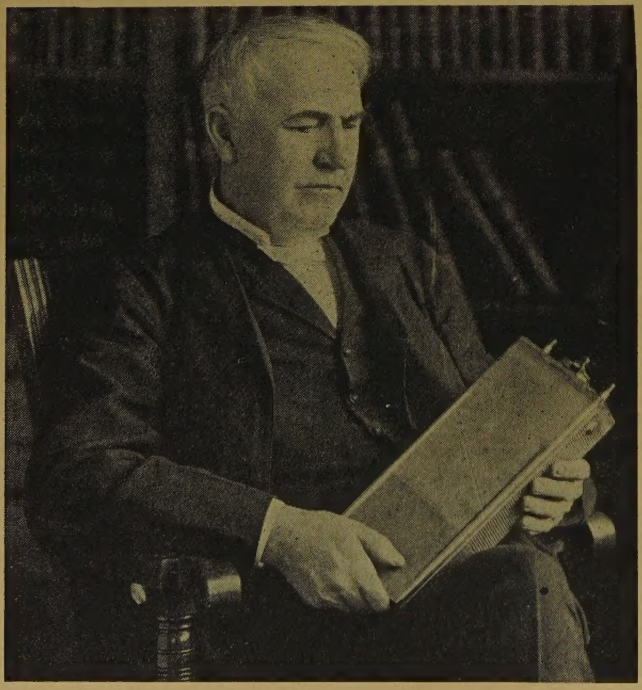
His disposition remained throughout life, sunny, kindly, and serene. In fact, he used to claim that his deafness was an asset, because it permitted him to concentrate his thoughts upon any desired object of study, even among intensely noisy surroundings. It was a remarkable vindication against fate, when this partially deaf man later discovered, invented, and perfected the phonograph.

In August 1862, an incident occurred which changed the direction of young Edison's career. The train on which he was newsboy was at Mount Clemens Junction, where freight cars were shifted. A box car was being shunted at considerable speed to a side track. The station agent's little son, 2-year-old Jimmie Mackenzie, had strayed to play on this side track, right in the way of the oncoming box car. Young Edison on the platform saw the danger. Casting aside cap and bundles, he jumped on the track and reached the child just in time to haul him clear. As it was, one front wheel of the car struck Edison's heel, and threw him with the child to the side of the track, on the stone ballasting. Their faces and hands were cut; but no serious injury had been incurred.

On the following day, Mackenzie offered to teach the lad Morse telegraphy, with a view to helping him secure a position as railroad telegraphist. Edison accepted, and in a few months, taking lessons three times a week between train times, together with practice at odd hours elsewhere, attained proficiency at the key.

For the next six years, Edison followed the career of a telegraphist. He became noted as a rapid and accurate operator, frequently being assigned to press work on night duty. He spent all his available leisure in experiment and study. Faraday's "Electrical Researches" particularly interested him, owing to their close dependence upon experiment, their imaginative appeal, and their freedom from mathematical symbolism. He also acquired, in the course of his journalistic daily work, and with his retentive memory, a large fund of general information.

**Edison and his nickel-iron-alkali storage battery**



### ENTRANCE TO EDISON'S CAREER AS AN INVENTOR (1868–1876)

In October 1868, when Edison was 21 years old, he applied for his first American patent—a vote recorder. This was a device which enabled the affirmative and negative votes of a seated voting assembly to be recorded swiftly and totaled automatically at the chairman's desk. Edison succeeded, after much effort, in demonstrating the invention at Washington, before the appropriate committee of Congress, only to find that there was no demand for a mechanism of that kind. Unsuccessful but undismayed, Edison returned to his little workshop in Boston. About this time, he gave up the career of a telegraphist, and devoted himself entirely to invention. He commenced with an improved telegraphic "stock ticker." Because he was able to repair a transmitting instrument of the Wall Street Exchange, he was made manager of the system, which he proceeded to improve and develop with new inventions. The new Edison stock ticker was a great advance in many respects over the earlier device, and brought him much renown.

A few days after Black Friday (a day of financial panic in 1869), he entered into the first recorded American firm of consulting electrical engineers, under the title of Pope, Edison and Company, 80 Broadway, New York.

After the successful sale of some of his inventions to the Western Union Telegraph Company, Edison opened machine shops at Newark, N. J., for invention and manufacture. He kept 50 workmen busy, and when orders came in heavily a night force also. He served as foreman for both gangs, which meant living on the premises and taking short periods of sleep at odd intervals during the 24 hours. Here he developed a number of telegraph inventions, in particular the quadruplex for sending and receiving four messages simultaneously over a single wire—two in each direction—and the high-speed automatic telegraph. During the Newark period (1870–1876) he took out nearly 120 American patents, almost all in electric telegraphy.

In 1871, Edison married Marg G. Stillwell, by whom he had three children, Marion E., Thomas A., and William L. Edison.

### MENLO PARK PERIOD (1876–1884)

Edison moved his laboratory from Newark in 1876, to Menlo Park, N. J., where he could concentrate on invention, since he found the combination of invention and manufacture too strenuous even for his energetic temperament. This was the year of the Centennial

Exhibition at Philadelphia, at which the new Bell telephone first was shown to the public. The original Bell telephone apparatus did not have a satisfactory transmitter, and Edison, after much experimental labor at Menlo Park, produced a carbon-button transmitter that virtually converted the telephone from an experimental to a commercially available apparatus. It was in his experimenting with the carbon transmitter that Edison coined the now well-known call word "hello" which spread out from Menlo Park until it became adopted by telephonists all over the world. He also invented about this time a new ingenious nonmagnetic type of telephone receiver because he was prevented from using the Bell electromagnetic receiver. It operated on the principle of electrolytically varied friction between two conducting surfaces in rubbing contact. This instrument, called the electromotograph receiver, had certain advantages in special cases and produced very loud sounds, but did not come into extensive telephone use.

In 1877, Edison discovered and developed the first stages of his phonograph or talking machine. Because of the pressure of other inventions, however, he was compelled reluctantly to set this instrument aside for a time, and leave its further development to later years.

In 1878 he took up the inventive problem of "subdivision of the electric light." At that time the arc light, originally discovered by Davy in 1809, had been developed and had come into commercial use for the illumination of halls and streets; but it was too powerful for interior use, and the problem was to substitute a number of small electric lamps for a single arc lamp. A number of inventors had already experimented with glow lamps or incandescent lamps; but no successful result had been achieved. Edison realized that a commercial incandescent lighting system would require its lamps to be connected in parallel. This required that each lamp should have a long thin high-resistance filament, a condition that greatly increased the difficulties of the problem. After a vast number of failures, his first partially successful lamp had a filament of carbonized cotton thread, mounted in a highly evacuated glass globe, with sealed-in platinum-wire leads. This lamp, in October 1879, glowed for 45 hours before breaking. After that, success gradually was reached. It came through overcoming, in succession, a large number of small difficulties, any one of which could have destroyed the project.

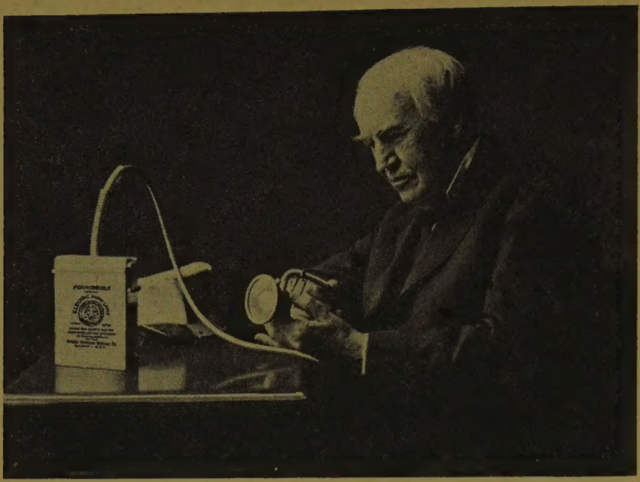
A new industry then had to be created from the Menlo Park laboratory results. A lamp factory, a dynamo factory, and factories for making operating instruments, testing instruments, and main conductors all had to be set up and standardized. The early lamps were all operated by voltaic batteries, and although there were dynamos for operating arc lamps, there was none in existence for operating incandescent lamps in parallel. Such dynamos had to be designed and built. These were at first driven by leather belts from the standard low-speed steam engines of that period, the speed of which, although

**Edison and an experimental model of the Kinetoscope, forerunner of the modern motion picture**

satisfactorily steady when driving factory machinery, fluctuated appreciably when used for incandescent lighting service. Edison realized that these belts could not be used in permanent reliable central stations, so new types of high-speed engines, with heavier fly-wheels, had to be developed for coupling directly to the dynamo shafts. After a number of small incandescent-lighting plants had been set in operation, successfully it was decided to open a central incandescent station in the center of the down-town business district of New York City, at 257 Pearl Street, with underground conductors. In all of this work, Edison was his own chief engineer.

The Pearl Street station turned on its current to the lamps in the district, September 4, 1882. It was successful from the first, the system gradually expanding over the whole of New York City. Although domestic gas lighting then was used generally, the new incandescent lamps won popularity through their steadiness, coolness, freedom from combustion products, and reduced fire hazard. About the same period, Edison incandescent-lighting stations and systems began to be developed all over the world.

Edison foresaw that the successful introduction of the incandescent lamp into factories and homes immediately would admit the use of the electric motor for operating machinery and household power devices. A few motors had already been employed on constant-current series-arc circuits, but the constant-speed self-regulating motor, taking power from constant-voltage mains, could not be produced until the incandescent lamp led the way. The first Edison motors were operated at Menlo Park in 1880, and rapidly developed on the Edison 3-wire systems, and in the Sprague electric-railway systems.



**The electric safety lantern**

There were several standard characteristics of the Edison system worked out at Menlo Park, that have remained but little changed to this day.

1. The lamp voltage, which he early set at or near 110 volts.

2. An interconnected system of underground iron pipes, carrying the insulated copper conductors which supplied the lamps. Edison realized that all these wires must go underground in large cities, and he faced the mechanical and electrical difficulties of that procedure, which were initially very great.

3. The division of the underground conductors into two classes: mains, which exclusively supplied the lamps; and feeders, which exclusively supplied the mains. By this means, a large saving was made in the total weight and cost of the copper conducting system.

4. The "3-wire-sytem," by which, although the conductors in the system were increased throughout from two to three, the total amount of copper in the system was about one-third, because all the conductors could be reduced considerably in size.

The demands of the electric light and power industry on Edison's time were so great that during his stay at the Menlo Park laboratory, he could give but little attention to the new discoveries and inventions which he was constantly making. One of these discoveries was in 1883, the "Edison effect." In later years, Fleming, De Forest, and others developed this into the thermionic tube, now so widely used. Another discovery, which he made at Newark in 1875, was a device for generating and detecting high-frequency electric waves. Edison's generator was a vibrating-contact induction coil, or even an electric trembling bell, with one terminal connected to water-pipe ground. The receiver contained electrodes consisting of graphite pencil points, the spacing of which could be varied. When one electrode was connected to ground, and the other to any short open wire, small sparks could be seen to pass between the minutely separated carbon points. These results were so different from those ordinarily associated with electric circuits, that Edison thought they might be some new phenomena, which he called "etheric force." It required long researches of later years, in various countries, to link Edison's experiments of 1875 with electromagnetic waves and radio communication.

### LLEWELLYN PARK PERIOD (1887–1931)

Edison moved his laboratory from Menlo Park to New York City, after his wife's death at Menlo Park, in August 1884, and he gave up his home there soon afterwards. In 1886, he married Mina Miller of Akron, Ohio. They made their home at Glenmont, Llewellyn Park, West Orange, N. J., and there they lived for the rest of his life. Their three children are Madeleine, Charles, and Theodore. Edison built a commodious laboratory in West Orange close to Llewellyn Park, and commenced work there in October, 1887.

At Orange, Edison perfected the phonograph and made a long series of inventions, including the alkaline storage battery, the moving-picture camera, synthetic rubber, the telescribe, the magnetic ore separator, various improvements in manufacturing concrete and other chemical products, as well as many war inventions for the United States Government. He developed his moving picture camera until he obtained some satisfactory reels of sporting contests. The moving picture of today acknowledges its start at the Orange laboratory.

### PERSONALITY

The outstanding qualities with which Edison impressed those who met him, were energy, frankness, courage, and kindliness. He was tall, and powerfully built, with a large head and a countenance open and engaging, but leonine in repose.

He was a terrific worker, especially before his 50th year. He would often work at his laboratory or factory for 20 hours at a stretch, with only brief pauses for meals, concentrating on one study at a time. His assistants worked in the same way, and he did not spare them, because he never spared himself. It was not that he actually dismissed assistants who did not work hard; it was the easy-going assistant who dismissed himself and disappeared from the picture. When engaged on some difficult problem like the incandescent lamp, he and his staff worked together days, nights, Sundays, and holidays, until they became unmindful of time. He was able to infuse them with his own enthusiasm.

When working regularly at a less feverish pace, he secured recreation from change of work. Above all things, he loved to invent some new or better thing than the thing he saw. He ordinarily carried about in his pocket a standard small-sized yellow-page notebook that might last a week. On the successive pages of this he would write down inventive ideas as they occurred to him, usually with some small illustrative sketch or sketches, together with the date and subject. He would stop in the middle of a meal or conversation, or immediately on awaking, to write out an invention. In the course of a day, he might make 20 such rough designs. They might be nearly all in the same field; or

they might differ greatly, depending much upon his surroundings during that period. One or two of these he would proceed to try out himself. The others he probably would distribute among his assistants to try out. He was ever incredulous about any invention that worked out successfully on the first trial, and always wanted to know what was the outstanding difficulty to be overcome. He was unfailing in encouragement and sympathy when difficulties beset an assistant's path, and suggested methods of surmounting them. Many of his first-sketch inventions proved to be impracticable, often for commercial reasons, and he did not expect more than a small percentage to survive laboratory tests; but fertility of imagination ran through them all. Moreover, he never sought to patent any process of which the inventive idea was not his own. More than 1,000 American patents were issued to him during his career; but these were only for the residual inventions that he selected as probably workable and economically capable of self-support. The vast majority never got beyond the notebook or the laboratory stages.

His method of attacking an inventive problem of major importance was always the same. He would attempt nothing until he had a clear comprehension of the existing state of the art, preferably from watching the latest process, or examining models; but otherwise by reading up the literature of the art. His memory for facts was most retentive, and he had acquired a habit of reading ordinary descriptive text by the line, instead of by the word, so that he could run through reports and pamphlets at great speed. He then would lay out in his notebook several plans for simultaneous experimental attack. As a confirmed optimist, he never doubted that an open path could be found for reaching the desired goal, provided that every possible plan was tried, regardless of established opinion or textbook authority.

His patience and tenacity in following up experimental improvements were most remarkable. He seemed to defy discouragement. He would spend weeks at a time on the improvement of the phonograph, teaching it, as he said, to say "specie." The delicate sybillant associated with the *c* was difficult for the instrument to render. It would return the word as "spee—ee." He succeeded finally to his satisfaction, but not without trying a very large number of devices.

In temperament he was simple, modest, direct, and kindly. It was impossible for him to pose or assume airs. Although his practical knowledge was extensive in many branches of science, he never claimed to be more than an inventor. With the alertness of his active mind, he tended to take a definite opinion on any proposition that might be presented to him; but he would listen very tolerantly to opposite views, and give way pleasantly to facts or demonstration. In general, however, his views proved to be reliable and based upon experience. He possessed a certain charm of manner which endeared him to his associates. Furthermore, he had the rare gift of securing the mutual good will of his assistants; so that dissension among them was very exceptional. It is admitted generally that he won esteem and good will everywhere. His only detractors have been those who did not know him personally.

At public receptions, he was shy and retiring. He dreaded to be called upon to make a speech. In private life, however, he showed a remarkable talent for humorous narrative, and he enjoyed listening to a good story. His life was a happy one. He was of very temperate habits, except in regard to hours of work. To the acquisition of wealth he was indifferent, except for the opportunities it brought for more inventions and accomplishments.

### TERMINATION

The long industrious and internationally famous career of Edison terminated by his death at 8:24 (Greenwich civil time) on the 18th of October 1931, in the 85th year of his age at his home in Glenmont, Orange, N. J. President Hoover, receiving the news on the battleship *Arkansas* in Chesapeake Bay, issued by radio a nationwide commemorative address.

On the evening of October 21, 1931, following his interment, it being also the 50th anniversary of his effective invention of the successful incandescent lamp, at the suggestion of President Hoover, the central station system lights were switched off for one minute over extensive areas of the North American continent as a tribute to the great inventor.

### PATENTS

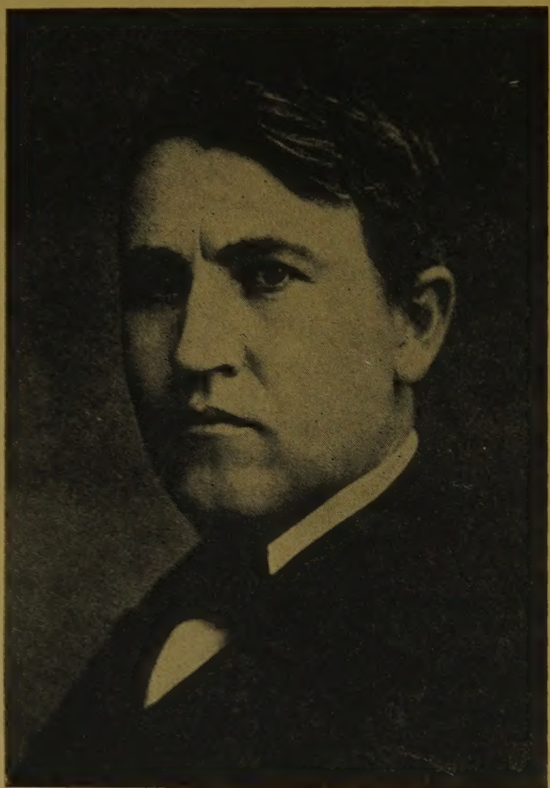
Between the years of 1868 and 1928 Edison was granted 1,091 American patents. Only two years, 1893 and 1894, elapsed without his securing at least one patent. A maximum for any one year of 107 were granted to him in 1882. During the same working period he also received up to 1910 1,239 foreign patents, distributed among 34 foreign countries.

**Edison and C. P. Steinmetz in a Schenectady laboratory**

# Edison and the AIEE

J. ELMER HOUSLEY
PRESIDENT AIEE

THOMAS A. EDISON was an active AIEE member from the time of the founding of the Institute to his death in 1931. He signed the circular which was issued in April 1884, soliciting support for the proposed organization of "The American Institute of Electrical Engineers." At the second meeting of the organization held May 13, 1884, election of officers was held. Edison, shown here as of that time, was one of the six vice-presidents elected at this meeting. He held office for two years, but because of dearth of Institute news printed in the early *Transactions* very little is recorded about his activities during this time.



Though Edison himself had no technical papers published in the AIEE *Transactions*, many of his assistants published papers on their work with Edison. The first technical paper was read before the AIEE at Philadelphia in October 1884 by Professor Edwin J. Houston and dealt with the then newly discovered "Edison effect." This paper is reproduced in this issue.

From time to time Edison was consulted about Institute activities. Many times he contributed his advice or congratulations.

Throughout the later years of Edison's life the AIEE paid its respects to his achievement on several suitable occasions. In June 1928, he was made Honorary Member of the Institute. He was one of the first five Americans to be elected Honorary Member, though there were a few foreign Honorary Members.

Another example of tribute paid by the Institute is the annual dinner of the AIEE in 1904 which was given in celebration of the 25th anniversary of the development and successful introduction of the incandescent lamp. The *Bulletin of the New York Edison Company*, March 1904, describes the event in part as follows:

"That the Edison dinner would be a success was a foregone conclusion—yet the American Institute of Electrical Engineers is to be congratulated. The success went far beyond anyone's expectation. . . . Mr. Edison receiving the enthusiastic greeting in his customary air of simplicity, shook his head and smiled with the expression 'I can't understand what all this is for.' "

Upon the death of Edison the Institute received messages from the entire world expressing its esteem of the great inventor. These messages were forwarded to Mrs. Edison. Some were:

"In the name of the Barcelona Branch of the Asociacion Electrotecnica Iberica (Spain), and by express wish of the Committee of the same, I (the assistant national secretary) have the honor of conveying to your Institution the expression of their deep sympathy with you in the decease of the distinguished inventor, Thomas A. Edison, by whose death the world suffers an irreparable loss."

"Regret passing of your illustrious member and brilliant inventor, Edison." (The South African Institute of Electrical Engineers.)

"Academic Council faculty members, Harbin Polytechnic Institute, Harbin, China, deeply regret decease great inventor, Edison. Express condolence."

"We express to you our heartfelt sympathy for loss of Edison. President, Institute Electrical Engineers, Japan."

"Elektrotechnicky Svaz Ceskoslovensky in Prague expresses their heartiest sympathy upon the loss of Edison, the greatest inventor of the world."

"Association Polish Electricians expresses to American Institute of Electrical Engineers profound and hearty compassion by reason of death of Thomas Edison, great man of science."

"The news of the disappearance of Edison though not unexpected has been heard with deep sorrow by the whole civilized world and particularly by all technicians who may better evaluate the enormous amount of genial work done by the great inventor, the great difficulties he has so often overcome, his organizing talent, his deep practical sense, the immense fecundity of his mind which have lead him to the solution of problems which were judged insoluble and which have rendered so rightly popular his name." (Associazione Elettrotecnica Italiana.)

The AIEE board of directors passed a resolution at their regular meeting held at Kansas City, Mo., October 23, 1931, in memoriam of Edison.

# TRANSACTIONS
OF THE
# AMERICAN INSTITUTE
OF
# ELECTRICAL ENGINEERS,

VOL. I.

MAY, 1884—OCTOBER, 1884.


*The "Edison effect" was the subject of the first AIEE technical paper, which is reproduced photographically here. This electron-emission phenomenon is the basis for the entire modern electronics industry.*

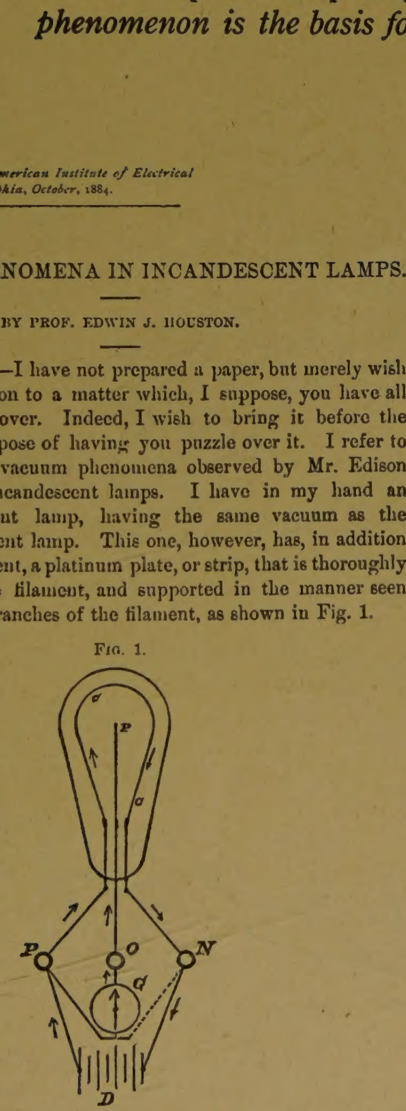
*A paper read before the American Institute of Electrical Engineers, at Philadelphia, October, 1884.*

## NOTES ON PHENOMENA IN INCANDESCENT LAMPS.


BY PROF. EDWIN J. HOUSTON.


Prof. HOUSTON:—I have not prepared a paper, but merely wish to call your attention to a matter which, I suppose, you have all seen and puzzled over. Indeed, I wish to bring it before the society for the purpose of having you puzzle over it. I refer to the peculiar high vacuum phenomena observed by Mr. Edison in some of his incandescent lamps. I have in my hand an Edison incandescent lamp, having the same vacuum as the ordinary incandescent lamp. This one, however, has, in addition to the carbon filament, a platinum plate, or strip, that is thoroughly insulated from the filament, and supported in the manner seen between the two branches of the filament, as shown in Fig. 1.

FIG. 1.




An Edison carbon filament, *c*, *c*, is placed inside an inclosing glass case in the usual manner. A strip of platinum foil, P, is supported as shown inside the loop. The binding posts, P and N, are connected to the ends of the carbon loop, and O to one end



of the platinum plate. P is the positive, and N the negative terminal of the electric source.

The lamp being placed in the circuit of any electrical source, as, for example, a battery, D, the current will flow in the direction indicated by the arrows. The galvanometer, G, has one of its terminals connected with the positive terminal, P, of the electrical source, and the other terminal connected with one end of the platinum strip, or plate.

P, representing the positive terminal, the current may be conceived as flowing through the filament in this manner. [Indicating.] If the ordinary current used in producing the light is passing, then no unusual effects are noticed. If, however, the current is increased, so that the incandescence of the filament is raised from its normal, say, eight candle-power, to twenty—, thirty—, forty—, fifty—, or one hundred candle-power, then the needle of the galvanometer is violently deflected by a current passing through its coils.

The question is, what is the origin of this current? How is it produced? Since we have within the globe a nearly complete vacuum, we cannot conceive the current as flowing across the vacuous space, as this is not in accordance with our pre-conceived ideas connected with high vacua. I should mention here, that if the galvanometer terminal, instead of being connected with positive, P, of the electric source, be connected with the negative. N, then we also have a current flowing through the galvanometer, but this time in the opposite direction. But in this case its amount is much less, being but about $\frac{1}{10}$ of the amount of the first current.

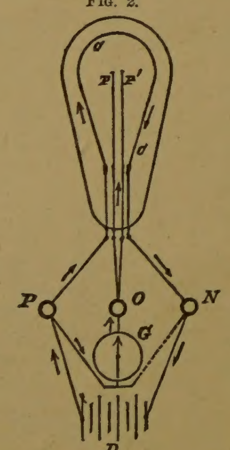
I have no theory to propound as to the origin of these phenomena. I make these desultory remarks merely because I wish to call your attention to the phenomena, if you have not already seen them. It is very clear as to the direction in which the current flows, when one end of the galvanometer is connected with the positive terminal, P. This I have traced by observing the direction of deflection of the galvanometer needle. The current flows, not as we might suppose, from the carbon to the platinum; it flows apparently in this direction, as if it came from the platinum. If it flowed as though it went from the carbon to the platinum, then it might be ascribed to various causes. It may be electricity flowing through empty space, which I don't think probable; or it might be the effect of what may be called electrical convection, if there is such a term. The Crookes' discharge from one of the poles might produce an electrical bombardment against

the plate, each molecule taking a small charge that might produce the effect of a current.

If we conceive, as I think most probable, a flow of molecules passing from the platinum to the carbon, then the phenomena may be readily explained as a Crookes' effect, since then we can regard a current as flowing in parallel circuit, from P, to N, through the carbon loop, and from P, through G, O, and P, to the carbon loop. But, remembering that the direction of the current is reversed, or apparently so, when the galvanometer is connected with the negative terminal, N, then the difficulty is to understand how the current there produced could possibly overcome the current from the source supplying the lamp. I should say here, however, that I am not entirely convinced from the few experiments I have tried myself, as to the actual existence of such a current. The deflection of the galvanometer needle, when connection was made with the negative terminal, being quite feeble. I am assured, however, that decided deflections have been observed.

I saw another lamp, in which two platinum plates are placed inside the lamp, but unfortunately I have not succeeded in finding the gentleman exhibiting it, so as to obtain from him an explanation of its peculiarities.

FIG. 2.



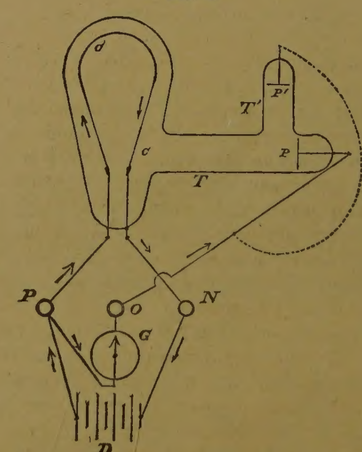

In this lamp, as shown in Fig. 2, the parts are the same as in Fig. 1, only two platinum strips, P, P', placed parallel to each other,



are employed. If a current is produced when the terminals, O, are connected with the galvanometer, then the phenomena is still more difficult of explanation. I believe, however, that one pole of the electrical source is always connected with the galvanometer, the other being connected with either or both of the platinum terminals. If such is the case, then the phenomena are simply modifications of the preceding.

I believe we shall find the preceding phenomena worth looking into. For my own part I am somewhat inclined to believe that we may possibly have here a new source of electrical excitement. That in some way the molecular bombardments against the platinum plate may produce an electrical current. At least, supposing it to be true that when the terminal, N, is connected with the galvanometer, the current through the galvanometer flows in the opposite direction to the current from the electrical source, it would seem that the phenomena could not be ascribed to the Crookes' effect.

FIG. 3.




Supposing, however, this opposite current out of the way, then a more careful inquiry may show the sufficiency of the Crookes' effect for the explanation of the phenomena. Indeed, an experi-



ment Mr. Edison has made, would appear to throw no little light on the matter. Instead of placing the platinum pole, P, inside the carbon loop, it was placed in the end of a long tube, T, T', forming a part of the lamp case. When the connections were made, as shown, with the platinum at P, so as to place it in line with the carbon, and, therefore, expose the filament to the bombardment of the molecules shot out from the platinum, the needle of the galvanometer was deflected, even though the tube, T, was surrounded by a freezing mixture. When, however, the platinum was placed at P', in the branch tube T', out of the direct line of the carbon, no effects were observed in the galvanometer.

I have brought this matter before you in this crude way, thinking it may be interesting, and that it might possibly elicit a discussion which would aid us in ascertaining its cause.

Mr. KEITH:—May I ask if the current always flows from the platinum plate towards the carbon?

Prof. HOUSTON:—I am not sure; I think in one case it flows from the carbon to the platinum.

Mr. KEITH:—That mystifies the matter still further.

Prof. HOUSTON:—Certainly.

Mr. KEITH:—It seems to me that there is a galvanic couple. It will be, provided that at all the times the current flows from the platinum, reaction may take place; or even if it flows from the carbon to the platinum, no matter whether constantly or not. The remarks that I was going to make are spoiled by lack of data on the subject.

Mr. PREECE:—Prof. Houston, may I ask you on what grounds you assert, or anybody asserts, that electricity flows in one direction rather than another?

Prof. HOUSTON:—Simply on the ground of its being a definite idea. I don't know that any one could prove that electricity flows more readily in one direction than another; but we have a convenient way of speaking of it as flowing from a higher to a lower potential. I think the facts would appear to warrant us in saying so. Of course, I do not know whether it is so or not. For my own opinion I would say that I think electricity is the transmission of chemical or atomic action, and I speak of it as flowing, or being transmitted, in a definite direction.

Mr. PREECE:—For that reason I asked the question, because there is no difference as to the use of the term or the definition or

value of the current; it is a pure convention. I do not think that we have any facts of any sort or kind to justify us in assuming that electricity flows in one direction rather than the other; but I would mention this, that in all recent inquiries that Crookes has made, and also Spottiswoode, before his death, they all had the tendency to show that if electricity does flow at all in any direction, that direction is rather from the lower to the higher potential, than, as we are all accustomed to admit and believe, from the higher potential to the lower potential. In other words, the tendency of the inquiry of Spottiswoode, De la Rue, and Crookes, and one or two German inquirers, whose names at present I forget, all rather tend to confirm your suspicion that electricity flows in the reverse direction to that which we are accustomed to admit.

Every other electrician present at the Exhibition, I think, has watched this experiment with very great interest. I feel puzzled in reference to it, and I feel that it is one of those things that wants to be very carefully and cautiously examined. It is also one upon which it is very dangerous to express an opinion. I was foolish enough the other night, when the experiment was shown to me at Mr. Edison's exhibit, to express an opinion, but I regret that I did so. However, I intend to exercise my persuasive eloquence upon Mr. Edison when I see him next week to induce him to give me one of those lamps, and when I go back to England I shall certainly make an illustration before our society there, and then make a careful inquiry into it. My own idea of electricity and the nature of this experiment is this: That for the production of the current you must have two things; you must have two points at different potentials, separated from each other by matter, and in this whether the direction be from the positive to the negative, or vice versa, is a matter of very little consequence; but to produce a current, as we have it here, we must have two points separated from each other by matter. The principal point here is what is that matter, and where is that matter.

I saw at Montreal an excessively beautiful experiment, tending to show that you had a Crookes' effect from platinum and carbon, just as much as we know that we have an effect from carbon and anything else. We know, for instance, in every incandescent lamp, that when you raise the filament to a certain condition of incandescence, there you have the Crookes' effect, because we see the carbon deposited upon the glass. But when we have platinum, it is a very difficult thing to prove that there exists the Crookes' effect. Dr. Oliver Lodge showed an extremely pretty experiment, to illustrate the fact that fogs resulted from the formation of moisture around a nucleus or molecule of matter. He took a large glass globe, apparently chemically clean, exhausted the air, but with moisture in it. It remained perfectly transparent as long as no matter was admitted, but the moment a spark from an induction coil was passed between the two platinum electrodes in this apparently chemically clean tube, at once a cloud was formed throughout the whole of the tube, showing that the passage of the spark between those two platinum points produces a Crookes' effect. That is, there was a bombardment of the platinum molecules, filling the whole of the tube, and the result was, the fog was formed. Now, here, suppose that that shall form, it may be, as has been suggested, that there is a new source of electricity. It may be it is due to something that we don't know of at the present. I am quite certain that we shall find the cause of this remarkable phenomena to be due to the Crookes' effect.



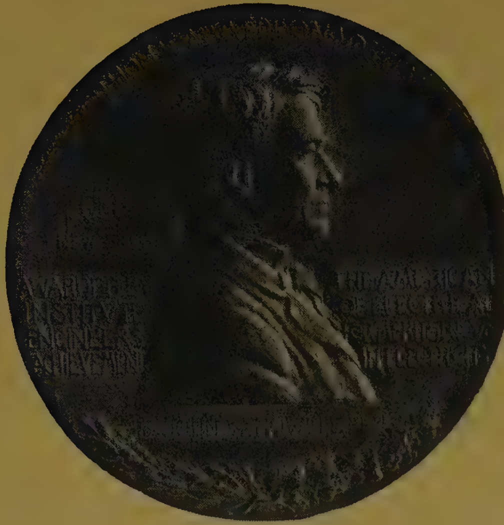
Prof. Houston:—I would like to say, in answer to the gentleman who has just spoken, that I am aware of the experiments that he has mentioned, some of which have been urged as proving the existence of a negative current. It seems to me that all they show is the transference of matter from the negative to the positive pole. Now, whether that constitutes an electric current or not, I do not think we can quite determine. The peculiar thing about the experiments I have mentioned is in the reverse direction of the current when the galvanometer is connected to the negative terminal. The difficulty exists, however, in finding a satisfactory explanation of the phenomena observed; whether the current is flowing from the positive or from the negative.

Mr. Keith:—Mr. Chairman, I think the remark, or word, the convention, of assuming a direction for the current, may be used in electrolysis. The current may be considered as carrying metal from the anode to the cathode, and thereby producing a deflection of the galvanometer needle, or a positive-direction wave constantly to the right hand, or to the left hand, as indicated by the deflection of the needle. However, I have often noticed in arc lamps this fact: when we have a very long arc there oftentimes comes a sweeping movement around the ends of the positive and the negative carbon, and there is a little flame proceeding from the negative carbon towards the positive, which seems to rise, and have its point, or beginning, as we may say, upon the negative, running up like a brush towards the positive. You have current enough to spread around this surface, or portion of the surface of the upper carbon, seeming to emanate from the negative and proceeding to the positive. It probably has been noticed by every-one who has worked the arc lights, that same phenomena, as though something was passing from the negative and going to the positive. This cannot be quoted as an illustration of the transference of carbon from the positive to the negative, as is manifested upon the negative carbon when the short arc is used.



Mr. Preece:—I think that some similar phenomena are noticed with the long platinum wire when it is raised to the state of incandescence. You find the heat commences at the negative end and flows in the other direction from some cause.

Mr. Kelly:—Some explanation ought to be given in reference to incandescent lamps at a high temperature. As to the current, I would say there is a discharge from one side of the carbon to the other. That is noticed to some extent in the same plate. Perhaps the induction is strong between the two sides of the carbon. Now, I don't see any special reason for supposing that when the platinum circuit is closed the discharge is interrupted; instead of passing from one carbon to the other, the discharge takes place between the negative side of the carbon and the platinum plate.

# The Edison Medal


S. M. DEAN
MEMBER AIEE


**Awarded for meritorious achievement in electrical science, engineering, or art, the Edison Medal is one of the greatest honors of the Institute. The medal was established at the AIEE banquet in honor of Edison and the 25th anniversary of the incandescent light. A part of the banquet program is reproduced on the adjacent page.**

THE EDISON MEDAL was initiated by a group of old associates and friends of Thomas Edison. They founded the Edison Medal Association and subscribed a trust fund in honor of their coworker and friend. At the annual AIEE dinner held February 11, 1904, the Edison Medal Fund and Deed of Gift were presented to the Institute to whom the responsibility of administering the award had been entrusted.

Originally the medal was to be awarded annually to a student for "the best thesis on record of research on theoretical or applied electricity or magnetism." However in 1908 the basis of award was revised. Accordingly the medal is awarded " 'for meritorious achievement in electrical science or electrical engineering or the electrical arts.' The award is limited to a resident of the United States and its dependencies, or of the Dominion of Canada."

Edison, though not always able to attend the presentation of the medal, often sent telegrams of congratulation to the recipients. A luncheon was given November 9, 1923, at the Engineers' Club, New York, for Edison and six of the ten living medalists. A silver replica of the Edison Medal was presented to Mr. Edison.

In 1926 the medal was awarded to William D. Coolidge "for the origination of ductile tungsten and the fundamental improvement of the X-ray tube." However, the Coolidge patent of ductile tungsten was judged invalid. Because Coolidge thought that this decision proved "that the best of men" could question his right to the medal, and because he "would not, for the world, do anything that could in any way detract from the luster of that medal, which should stand for generations to come as one of the most coveted prizes for meritorious work in the electrical field," he refused to accept the medal. In 1927 the medal was awarded to him "for his contributions to the incandescent electric lighting and the X-ray arts."

The gold medal is $2^{11}/_{16}$ inches in diameter. A bronze replica is also supplied with each award.

Awards of the medal have been as follows:

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|---|---|---|---|
| Elihu Thomson | 1909 | Charles F. Scott | 1929 |
| Frank J. Sprague | 1910 | Frank Conrad | 1930 |
| George Westinghouse | 1911 | E. W. Rice, Jr. | 1931 |
| William Stanley | 1912 | Bancroft Gherardi | 1932 |
| Charles F. Brush | 1913 | Arthur E. Kennelly | 1933 |
| Alexander Graham Bell | 1914 | Willis R. Whitney | 1934 |
| Nikola Tesla | 1916 | Lewis B. Stillwell | 1935 |
| John J. Carty | 1917 | Alex Dow | 1936 |
| Benjamin G. Lamme | 1918 | Gano Dunn | 1937 |
| W. L. R. Emmet | 1919 | Dugald C. Jackson | 1938 |
| Michael I. Pupin | 1920 | Philip Torchio | 1939 |
| Cummings C. Chesney | 1921 | George Ashley Campbell | 1940 |
| Robert A. Millikan | 1922 | John B. Whitehead | 1941 |
| John W. Lieb | 1923 | Edwin Howard Armstrong | 1942 |
| John W. Howell | 1924 | Vannevar Bush | 1943 |
| Harris J. Ryan | 1925 | E. F. W. Alexanderson | 1944 |
| William D. Coolidge | 1927 | Philip Sporn | 1945 |
| Frank B. Jewett | 1928 | Lee de Forest | 1946 |


**S. M. Dean** is the chairman of the Edison Medal committee and chief engineer of the system, The Detroit Edison Company, Detroit, Mich.

# ORDER OF EXERCISES

▾

*Salutatory by the President*

MR. BION J. ARNOLD

*Presentation of the Edison Medal Fund and Deed of Gift to the Institute by*

MR. SAMUEL INSULL

*Chairman Edison Medal Association*

*Acceptance of the Edison Medal Fund and Deed of Gift on behalf of the Institute*

PROF. A. E. KENNELLY, PH. D.

*Past President*

*Toastmaster*

MR. T. COMMERFORD MARTIN

# The Issue—Mutual Survival

E. WIGHT BAKKE

**During the past ten years the labor–management problem has become one of major concern. To provide some basis for analysis, the author has interviewed approximately 60 leaders in each field and has prepared a summary of their reactions to the problem. The main difficulty seems to be an inability, or unwillingness, for either side to understand the other's position or to modify its own. The article emphasizes the importance of mutual understanding and a common aim—mutual, not separate, survival.**

During the last ten years millions of workers joined unions for the first time, thousands of them were elected to offices for which they had little training, and thousands of employers for the first time had to readjust their operations to make a place for unions. Even employers and labor leaders who were old hands at collective bargaining never had operated on such a broad front. Making collective bargaining work was a task of staggering proportions. It was not only that people had to learn how to negotiate. The difficulty went deeper than that. The negotiator did not really understand why the other fellow was compelled to act as he did. Labor leaders did not always understand the job of management, and management did not always understand the job of labor leaders. Even when there was understanding, the people down the line in the organization had little conception of the practical problems, the responsibilities, the traditional codes and practices, the convictions which had been developed by each group in "the school of hard knocks" in which it had received its training.

Both knew that they had to learn to live and work together. They realized that the industrial warfare which preceded widespread collective bargaining had left a lot of bitterness and distrust on both sides, but they hoped that such feelings would be ameliorated when they became better acquainted and attacked their common problems. The difficulties that have arisen, though, are making many of them wonder whether they were not overoptimistic. As they look ahead the problems seem to be on the increase, not on the wane.

In the fall of 1945, I visited nine major industrial centers and interviewed about 60 leaders in management and 60 leaders in the unions. I asked each of them what his chief difficulties were in dealing with the other. But I tried to go further and learn from their answers how each regarded his job. What was management's convictions about workable industrial relations? What were the union leaders' convictions about the basic nature of unionism? Why were these convictions what they were? How were they rooted in the job each had to do in order to survive?

I could not avoid a major conclusion. At the basis of most specific difficulties reported was that both management and union leaders were expecting each other to behave in a way which the other regarded as impossible if he were to survive. Each was expecting peace on terms consistent with his own sovereignty. To be more specific, management anticipated peace when the unions became the kind of organization which fitted in with management's conception of the principles of workable industrial relations. Union leaders expected peace when management accepted and bargained in good faith with unions as they were in their essential characteristics. Both were willing that their tactics and strategies should change, but not the principles of sound management on the one hand or the principles of effective unionism on the other. That was a natural reaction because those principles on both sides had grown out of experience. They were the end products of trial and error. Men knew their jobs, their responsibilities, and the rewards they could expect if they operated that way. It was a stubborn reaction because men identified the survival of their organizations with the maintenance of those principles.

The plain fact is that management's convictions about sound management and the union leaders' convictions about effective unionism do not fit together at important points. Some one is going to have to modify his convictions enough to make workable mutual relations possible unless there is to be a struggle for dominance. It is not my purpose to suggest whether one or the other, or both, must give way. My simple objective is to place the two sets of convictions side by side in order to demonstrate the basic nature of the conflict between them, and to indicate the prospects for the reduction of that conflict.

## MANAGEMENT GUIDEPOSTS

What is management's idea of workable industrial relations? Briefly summarized, the points that stand

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Essential substance of an address before a meeting of the Yale Engineering Association, New York, N. Y., November 8, 1946. The address was based upon "Mutual Survival—The Goal of Unions and Management" by Professor Bakke, first interim report of the Yale University Labor and Management Center.

**E. Wight Bakke** is Sterling professor of economics, Yale University, New Haven, Conn., and director of the Labor and Management Center, Yale University. He formerly was chairman of the appeals committee of the War Labor Board.

out, almost without exception, in management's discussion of its problems are these:

1. Industrial relations are primarily and basically a matter of relations between management and employees, its own employees.

2. The first objective of industrial relations, like that of every function of management, is the economic welfare of the particular company.

3. Industrial relations arrangements must leave unimpaired management's prerogatives and freedom essential to the meeting of management's responsibilities.

4. All parties to industrial relations should be businesslike and responsible.

These are the guideposts by which management determines whether it is on the road to sound industrial relations. Management believes that if the unions will stay on that road collective bargaining can be made to work. However, if the convictions of labor leaders about the essential nature of unionism turned out to be an accurate reflection of what unions have to be in order to survive, could they follow that road? That is the question I want to raise.

Consider management guidepost number one: Industrial relations are relations between a particular management and its own employees. Labor is "our men," not workers in general, not members of the union, not "organized labor." The union has a legitimate function on the basis of this principle only as the representative of, or spokesman for, "our men," and as a medium of communication with them.

Two features of unionism are incompatible with this management position. The first is that the union normally represents members in many companies throughout the industry or occupation. Every expansion of the union into new territory increases its task of representing and maintaining group solidarity among all workers in its jurisdiction. More and more, unions must be guided by that fact and not merely by their responsibility as a spokesman for the employees of a particular company.

In the process of doing this the second characteristic of unions becomes clear. They develop an institutional life of their own beyond the lives of individual members. A basic objective of that development is strength and power and prestige of the union as such. Internal conflicts must be ironed out. The membership must be bound together by a common philosophy and achievement. Power of many sorts has to be acquired. Protection against competing unions must be sought. A strong internal government and leadership must be developed. Faced with such problems, the union officers cannot come to the bargaining table merely as spokesman for the employees of a single company. Every demand, every counterproposal, every compromise, must be measured against the need for survival and growth of the union itself. Even the degree to which the clearly expressed wishes of the employees themselves can be followed by union leadership must face that test.

Unions never will fit completely into this first principle of management's conception of industrial relations. With unions in the picture, the issues in industrial relations never will be reducible solely to matters affecting the welfare of "our men." Management would abdicate from a major role if it did not insist continuously on referring adjustments to that standard. Moreover, the unions cannot afford to forget their own primary interest in representing the interests of employees of particular firms; for the satisfaction of those interests is the foundation upon which their reputation for service must be built. But union leaders are convinced that even service to local groups is not a product merely of presenting persuasively to local management the expressed wishes of local groups. It is a product of the ability to back their arguments with a power broadly and firmly rooted in a supporting membership throughout the industry or occupation, and in the organizational strength of the union itself.

### OBJECT OF INDUSTRIAL RELATIONS

The second management guidepost points to the objective of industrial relations. The objective, like that of every function of management, is the profitable operation of the particular company. The management of industrial relations, no less than the management of financing, production, or marketing, must add up to an efficient and profitable enterprise.

Any manager, whatever his philosophy or degree of benevolence, will get tough when the productiveness and profitability of his own firm starts going down. The job for which he immediately is rewarded or punished is promoting the welfare, not of the world, not of the national economy, not of the industry, but of his own company. This does not mean that he is unconcerned about these larger matters. It simply means, inasmuch as industrial relations are one of the several problems of the enterprise for which he is responsible, that his dominant interest is in their impact upon his own enterprise.

A union, in representing a broad membership and in maintaining its own existence, necessarily raises issues which extend far beyond the particular problems of the particular company. The welfare of the entire membership and the strength of the union as such seldom depend solely upon what happens to any particular firm.

For example, when the union demands a guarantee of exclusive or even continuing membership, or the "check-off," in order to strengthen itself, many employers have said, "If you can sell yourself to our men, you can become strong. But that is your problem, not ours."

The union frequently argues wage possibilities in terms of rates of other firms and industries and localities whose internal problems are considerably different from those of the particular company involved. Sometimes they demand industry-wide terms. They raise the issues of aggregate purchasing power, full employment, human rights, the American standard of living. The manage-

ment which is preoccupied with the internal problems and structure of its own company is likely to say, "What does that have to do with my problem?"

The conflict between management's idea that industrial relations are primarily a part of the operations of an individual company, and the tendency on the part of unions to introduce considerations which are beyond the effective control of a particular management, is not an insurmountable barrier to effective collective bargaining. Management deals with banks, power companies, suppliers, and dealers, who have interests of their own which determine their attitude in bargaining with management. Moreover, prominent management leaders constantly are urging employers to expand their interest in and concern for many of the problems which the union injects into the bargaining. To the extent that the economy and society become more complex, the welfare of the whole and that of the individual firm are bound more closely together.

Misunderstanding between the leaders of labor and management, however, can be reduced if labor leaders are aware of the fact that management has to put the effectiveness of its own operations first, and in some cases to reject as irrelevant the union's standards of comparison and its own needs for survival; and if leaders of management recognize the compulsion upon unions to chart their course by reference to such considerations. For while they may appear irrelevant from the point of view of a particular management, they are often exceedingly relevant from the point of view of the strength and power of the union and the interests of the workers whom the union represents.

### MANAGEMENT FREEDOM

The principle written on the third management guidepost is carved deeply. It is this. Arrangements in the field of industrial relations must leave unimpaired management's prerogatives and freedoms essential to the meeting of management's responsibilities.

It is natural, and indeed necessary, for management to make this point clear. It is its claim to the right to survive. It is particularly understandable in view of the traditional freedom possessed by management to follow its own inclinations and wisdom with respect to obtaining, organizing, and directing a working force. As long as management practice and policy made it possible within the law to obtain and hold a working force with which it could produce and market a profitable product, little restriction was placed upon managerial discretion. Law, the decisions of customers, and pressure from fellow managers were the chief external restrictions. Collective bargaining, however, introduced a host of additional impediments to free action. Almost all functions of management, even those which are not concerned with the direction of workers, have become the subject of trade agreements or have been affected in important ways by such agreements.

A large part of management irritation with this development arises from specific restrictions on such items as discipline, hiring, transfers, work assignments, promotions and demotions, layoffs, the establishment and administration of work schedules and production quotas, organizational and technological innovations, the setting up and administration of wage systems, and like matters. Particularly irritating to many managements is the denial of their freedom to reward or punish individual workers in accordance with management's estimate of their individual merit and promise. Even in cases in which satisfactory working agreements have been made on such issues, management is disturbed by delays and restrictions upon quick decisions considered essential in the operations of the company. Beyond the specific restrictions involved, however, is the anxiety felt by many managers about the future; uncertainty as to where this process will end; a fear that it eventually will culminate in such stringent impairment of management's freedom that it will not be able to do its job satisfactorily.

### UNION REINS ON MANAGEMENT

I have found no indication among labor leaders that they want to run the business or that they have a conscious plan to share with management the control of all features of the enterprise. But there are two features of unionism which promote tendencies which might seem to move in this direction.

A union is an employer-regulating device. It seeks to regulate the discretion of employers, as one union leader said, at every point where his action affects the welfare of the men. Those points cover a broad area. In one sense there is not a single managerial function which does not fall within that area. Where will the process stop? Where can it stop if the union is to fulfill its basic objective of controlling collectively all those industrial policies and practices which affect the welfare of the men? Certainly, union leaders have no clear cut definition of the boundaries of this area. I doubt, on the basis of responses from management to my questions, whether any representative group of managers could agree upon precise boundaries.

The second feature of unionism which inevitably restricts managerial freedom is this. The union is a device to reduce or eliminate competition among workers by establishing uniform rules and standards and compelling individual workers to conform to them. In other words, the union purpose and policy is to eliminate individual bargaining. Union leaders believe that is an essential principle of unionism and collective bargaining. Unless a union can persuade or compel men to say "On these terms and no others will we accept employment," it has left the door open to just that competition among workers which it was set up to eliminate. The bargaining power of the group as a whole is destroyed. The essence of union strength is a solid front on the conditions and terms of employment.

## FREEDOM AND REGULATION

How far will this limitation of management freedom go? Is it an inevitable trend which will not be brought to a halt, short of placing management in a strait jacket bound by which it cannot discharge its responsibilities, let alone make progress? It is hard for many employers to be optimistic about the outlook. The following is a summary of several suggestions made by a number of labor and management leaders who have devised workable arrangements in this matter.

The end of this conflict between management freedom and union regulation is not in sight. But one thing is clear. Management and union leaders who have made some progress toward a solution have not done so by arguing in terms of management "prerogatives," union "rights," and "workers interests." They worked on a less abstract level. They dealt with specific and practical definitions of the points at which management had to retain absolute control and the points at which it could share control. They focused their attention on the practical job to be done. Was joint operation or a division of labor the best way to do it? And they each were willing to resolve any conflict by an arrangement which would meet the practical, if not the abstract, needs of the other.

The leaders of the labor movement in the United States, with the exception of communists, are not guided by a definite philosophy on this point. They are opportunistic and pragmatic in their policy and practice. How far they go is guided by practical needs, not by any revolutionary philosophy. This fact leaves some room for hope.

One labor leader put into words an impression I got from many others. He told me that he could see this increasing restriction on management operations in almost any series of annually negotiated local contracts. Whenever he saw an added restriction, however, he said to himself, "Oh, oh, the boys had trouble or sensed trouble on that point last year." He went on, "You see, after the basic terms of employment are brought under collective control and mutual confidence is established, control at other points usually is a response to some actual or anticipated abuse of managerial discretion. If they use it to undermine the union, or pit man against man, or if the men become heated up about some way they operate, why then we have to climb in and put on the screws at that point. We do not want to run the business. We want to remain free to kick and to put pressure on management."

Employers who think they see light on this problem tell me this: if they give continuous attention to the impact of their action upon the stability of the union, upon the willingness of the workers to abide by common standards, upon the satisfaction of employees with their working conditions, they will be able to judge more accurately whether any policy or practice is likely to stimulate further demands for union participation in these matters.

I am not indicating that all stimulus for such participation arises from acts of management. I merely am pointing out that the basic drive of unions is to bring an increasing area of the operations of the enterprise under the control of collective bargaining and that the drive frequently is increased by what management does.

Union leaders are acting in accordance with the basic principles of unionism in seeking to impose rules on management and to reduce competition among workers. The process itself and not its end result absorbs many of them at the moment. That is natural, particularly in the early stages of organization. But thoughtful labor leaders tell me that the time has arrived for a serious estimate of the effects of that end result upon management's ability to do its job. It is only common sense, say these leaders, that if the unions expect management to be interested in the effect of its action on building effective unions, that unions in turn should demonstrate an intelligent interest in the survival requirements of efficient management.

This conflict promises to be one of the most troublesome in the entire field of labor and management relations. It is particularly so because fundamental principles and survival needs are involved on both sides. Industrial peace and workable collective bargaining will depend greatly upon whether both parties can reconcile their principles on this score. Can they look upon their convictions not as absolute and eternal but as modifiable in the interests of workable arrangements, permitting each to survive and get on with his work? Management and labor leaders alike will have to test their actions by this question, "If I do this or insist on this arrangement, will it be possible for the other fellow to do his job well?" How well each can do his own job depends upon how well the other fellow can do his.

The final point in management's conviction about the essentials of industrial relations is that all parties should be businesslike and responsible. Much of what management says about union responsibility is another way of expressing its conviction that unions, in their dealings with management, should be businesslike. This, they insist, is a reasonable expectancy. But its realization is not as simple as it sounds. I think it is well to recognize that management's definition of "businesslike" and "responsibility" grows out of its own experience in doing business; that what is meant is "following the rules of business." This is no place for an extended dissertation on those rules but certain of the more important of them should be recalled. What are they?

## "RULES OF BUSINESS"

First of all, parties to a business arrangement should be free to accept or reject any offer or proposal on the basis of their interpretation of the benefit of such action to them. There should be no compulsion upon them to

do otherwise. There is no place, at least in the theory of free business competition, for duress exerted by one party upon another. In the second place, all affairs should be conducted upon the basis of reasonable and orderly procedures which are understood and accepted by both parties. In the third place, the bargains made through these processes should be reducible to definite contracts equally binding upon both parties. In the fourth place, those who make the contracts should have the ability to deliver and to hold any parties for whom they are agents to the arrangements made. In the fifth place, if they are not able to deliver, redress should be available through agreed upon penalties voluntarily accepted and, if not, enforced by the courts.

These rules are accepted pretty generally as being representative of fair business practice. Where did they come from? Their source is in business experience. They are the rules which embody the wisdom of that experience in dealings between businessmen. What I would like to suggest is that the businessman's definition of businesslike conduct and responsible conduct is that which he has found satisfactory in governing the relations between manufacturing concerns, banks, insurance companies, dealers, brokers, and the like. People who manage such institutions are motivated and guided by primarily business considerations, those of economic gain or loss. Their code of conduct is a response to that fact, although it may be an excellent code of conduct from a moral and from a practical point of view.

Moreover, because business is so important a part of our common life, such rules are applied pretty generally to all human relations. In a business civilization the code of business dealing tends to be imposed on every one. I am not suggesting that it should be otherwise, particularly when people are making business deals. But persons who are not primarily businessmen, and institutions which are not solely business organizations, have nonbusiness problems. Sometimes what they have to do cannot be done by following the rules of business. They develop a code of their own which does not always agree with the businessman's code. If the businessman has to do business with such people or institutions, he naturally is exasperated. But a practical solution is more possible if he understands why the other behaves as he does.

### ARE UNIONS BUSINESS CONCERNS?

Suppose a union is judged to be not primarily or exclusively a business concern—what then? Would its leaders feel as thoroughly committed to the rules of business?

There is a large element in the function of the union which is definable as business operation. A union is in part a business institution, but it has other features which keep it from being purely a business organization. The following are a few of the characteristics which are prominent in union leaders' conceptions of unionism, and which, when added together, raise a serious question as to whether unions ever will be guided solely by the code of business operations.

A union is a part of a working class *movement*. A movement is not a business. To the degree that workers are integrated thoroughly with it, they are bound by psychological ties of loyalty, not only to a particular union but to the movement with its traditions, folklore, and symbols. There is nothing in the world of business which compares exactly to the song books, the banners, the pilgrimages, the traditions of struggle against exploitation, the folklore of martyrdom, the poetry and literature which mirror in their various phases the psychological sentiments which hold a movement together and motivate much of the conduct of participants. A movement is not a business, although it may have business functions to perform. Loyalty to this movement on the part of a significant nucleus of union men very frequently will cause them to set aside purely business considerations and to adopt tactics which are anything but businesslike.

Again, a union is a pressure organization originating in the desire on the part of a group of people with relatively little power to influence the action of a group with relatively more power. The words "struggle" and "fight" and "battle" and "crusade" are not merely a part of the vocabulary of union organizers. They are symbols of the conception which these men hold of their own task, symbols made vivid by their life experience. The tactics and policies of today are molded by the experiences of yesterday.

Furthermore, a union is a device for continuously changing the balance of fundamental economic rights and rewards in favor of workers. A business is a device for obtaining economic advantages within the framework of established rights. But it is one of the major functions of unions to alter the balance of these rights and rewards as between employers and workers. The changing of fundamental rights, at best, is more of a political than a business procedure. In many cases, its tactics point more in the direction of warfare than in the direction of trade.

Finally, a union is a political institution in its internal structure and procedures. The solidarity of its participants is affected, not by the businesslike procedures of hiring and firing, the giving and withholding of economic rewards, but by the techniques well known to political leaders. A moment's reflection upon the methods of political machines and the conditions of their survival will demonstrate very well the difficulties preventing unions from ever becoming pure business organizations. Or consider an analogy from business itself. Suppose management had to obtain the consent of stockholders to practically every decision it made. Suppose that the operations of management involved the constant and detailed activity of stockholders. Suppose that a stockholder, dissatisfied by this day to day activity, could object, not by selling his stock to someone else but by

actually withdrawing capital from the business. Management then would be compelled to develop in relation to their stockholders the same kind of political strategies which union leaders must develop in relation to their members. The ability on the part of management to make binding decisions which it had the power to carry through in its dealings with others would be complicated immensely if it had to depend on detailed support and co-operation from stockholders in order to implement its decisions. Management–stockholder relations would become political, not solely business relations.

If it is understood that unions internally are political organizations, then much that is referred to as unbusinesslike or irresponsible conduct may be set down as the behavior of a political institution which as yet has not solidified and regularized its own structure or become adapted to the task at hand. I can imagine, for instance, that if a large city were to be run by the methods of town meeting democracy, that the confusion and ineptness and inadequacy of the actions taken conceivably might be labelled as irresponsible by those accustomed to a city manager form of government. Labor leaders, whose personal character, integrity, and reasonableness are beyond question, face a most difficult task in demonstrating their responsibility to management, for such demonstration must be made through the medium of the political institution of which they are a part. There is no democratic short cut to the development of well-integrated and disciplined political institutions.

These features of unionism retard, if they do not make impossible, the development of unions completely responsive to the principle of businesslike dealings and responsibility so important in management's conception of industrial relations. They are not cited in order to demonstrate an ultimate incompatibility between unions and this conception, but to indicate the character of the problem faced.

It is a difficult problem, but I have met men in unions and in management who think it is not insurmountable. They are living with it and making some progress. What are the points on which they are agreed; how have they approached the problem?

They agree that, whatever the nature and backgrounds of management and unions, collective bargaining is largely a business process, particularly after the union genuinely is accepted as a participant in the enterprise. Hence it is not unreasonable to expect both parties to be businesslike and to act responsibly in observing business contracts. If the contract proves unsatisfactory to either party, the thing to do is to correct the situation when a new contract is made, not to "chisel" on or tear up the present one. That attitude is basic.

## EVOLUTION OF A CODE

The second point is equally important. It takes time for men and institutions to adapt their code of behavior to the realities of their relationships. The code of business dealings was not produced in a day. And it was not embraced immediately by all businessmen. Even today the observance is not 100 per cent. Historically, business enterprise, itself, replaced forms of the struggle for self-maintenance which were more warlike and predatory. Many generations were to pass before the modern code of business was produced and won general acceptance. Businessmen have at least 100 years' start on union leaders in the traditions of contract-making and contract-keeping.

In the third place they approach the problem realizing that men tend to accept that code which rewards them. Businessmen accept this code because, in the kind of world in which we live, they are rewarded in the achievement of their basic objectives by observing it. If the unions accept it, it will be for the same reason. It is possible that the objectives of some unions are such that they cannot be reached by the utilization of purely business methods, which is another way of saying that businesslike methods and codes alone may not be able to reward them. But as the major features of exploitation and inequalities are reduced in importance on the American industrial scene, as the memories of past struggles become less vivid, and as unions are accepted as legitimate participants in business enterprise, it should not be beyond the realm of reasonable hope to anticipate that responsible, businesslike action would prove more rewarding to unions than its opposite.

Unions, after all, have to deal with businessmen. Much of their activity is a business operation. The business code is a hard fact to which they must adapt themselves. But any code which is mutually acceptable has to be mutually workable, that is, it has to be mutually advantageous and rewarding.

Another point of agreement between men who appear to be making some progress on this matter is the recognition that the code itself is not an eternal law. It still is changing. As it has to be satisfactory to both parties to the relationship which it governs, the interests, the problems, and the necessary behavior of any new party have to be considered. When they are, the code undergoes change, possibly for the better. It is no criticism of the business code to say that it grew up to govern relations between men who were producing or exchanging property and commodities with economic gain in mind. Even the labor contract was supposed to be one for a sale of and payment for a commodity, namely labor skill. The worker was a businessman marketing what he had to sell, which means he was marketing himself, a human being, not a bar of steel, or a package of corn flakes. Unions are not solely responsible for putting that idea across, but their influence in changing the code on the point can not be ignored. Unions also have had their own codes modified by experience in business dealings.

Said one labor leader, "I was trained as a fighter for human rights. I am not forgetting that. But there are more ways than one to fight. It comes down to a ques-

tion of method. If you can win your point by negotiation and making better contracts every year, why trot out the artillery? But there are rules to follow if the method of negotiations and contracts is to work. The employers I deal with have had a lot of experience in developing rules that fit that method. I've profited by their experience. The rules do not always fit the human relations involved, though. But if I want the method to work, it is my job to make the rules fit, not to throw them completely out of the window and grab the employer by the throat."

The point is that the code of business is an evolving code. It can be made a better one if it fits the realistic nature of the human relations which it governs. Collective bargaining has provided the opportunity for some employers and labor leaders to become acquainted with those realities and to make the code better and more workable.

### ORGANIZATIONAL RESPONSIBILITY

Another point made by these men who think they are making progress is this: The observance of contracts, much more than their negotiation, depends, not so much on the character of officers as upon the organizations they lead. The charges fly from both sides, "The fellow at the top means well, but the men down the line have different ideas. Then what happens to the contract you have made?" Those charges underscore the point. Both management and unions can be really responsible only to the extent that the whole organization is back of and acts in line with the decisions of its leaders. Both have a job to do on this score. Management has some advantage in the fact that its structure of organization is better established and that "the fellow at the top" can replace the "men down the line" if they resist persuasion. Union leaders have greater difficulty in firing those who upset the apple cart. The organizational structure of a political institution like a union is upset more easily than that of a business, unless the union officers want to throw democracy overboard. One of the biggest problems on the minds of the union leaders I have met is the development of internal political structure, techniques, codes, and discipline. By this they mean techniques for exploring the needs and wants of members, the establishment of recognized patterns of leadership and authority, the development of a disciplined citizenship within the union, committed to action in accordance with the decisions of their representatives.

The final point made by these men is that in this period of learning to live and work together, a good many rough spots can be made smooth, inevitably inadequate machinery can function better, and conflicting codes cause less damage to good relations, if labor leaders and management can associate and get to know each other in ways other than as bargainers or grievance settlers.

Finally, two points should be made clear. I have made no judgment about what is right and what is wrong, either in management's convictions about the essentials of industrial relations or in the convictions held by union leaders about the essentials of unionism. I do not know what is right or wrong. But I am certain of one thing, nothing is right which will not work; and arrangements that work are going to have to be reconciled with these convictions and survival needs on both sides. Unless methods are adapted to such realities we presently shall find ourselves repeating the words of the March Hare in "Alice in Wonderland," when he tried to fix the Mad Hatter's watch with butter. When his method did not work, he only could express his bewilderment in these words, "And it was the *best* butter too, the very *best* butter."

In the second place I have offered no solution for reconciling those convictions. That solution will have to be hammered out by practical men in the light of the whole set of problems they face. I do not know all those problems. I never have met a payroll for more than 16 people and I never have organized a union. Every suggestion I have made has been relayed from practical men of experience on whose shoulders rests the responsibility for practical action. But there is one final observation I would like to make as an impartial onlooker.

### AIM IS MUTUAL SURVIVAL

It is exceptionally important for both the representative of management and the labor leader to know the kind of a job and responsibilities faced by the other, and his convictions about what is required if he and his organization are to survive. Men will fight when they believe their survival is threatened. The first task of life is to live. I am convinced that the great majority of employers and labor leaders alike are not out to break or to take over the other. But they can do that without intending to do so by fighting for their own survival in ways which endanger the survival of the other. The end result will be the overwhelming of both free management and free unions. The chain of events is clear. If either union leaders or management expect, or try to force, the other to be what they honestly believe they cannot be and survive, they will arouse the fighting opposition of the other, bring out the very belligerent and stubborn characteristics which make peace impossible. If two such giants as organized labor and organized management engage in a struggle for dominance within the highly delicate mechanism of the American economy, neither can win and democracy is bound to lose. They will go down together in the resulting chaos or in the regimentation which will arise from public demand to avoid chaos. Free unions, free management, free enterprise, and a free society will survive or go under together.

Mutual survival, not separate survival! That is our common aim. If we keep it steadily before us we can avoid a fanatical struggle for dominance which can never be won within a democracy.

# Industrial Future of China

V. K. WELLINGTON KOO

In recent years the question of the future industrialization of China has aroused great interest and much discussion. This is perhaps only natural as China, with her colossal population and immense potentialities in natural resources, is a land of great promise. Before peering into the future, however, it is necessary to take a look at the background of China's industrialization.

In the middle of the 19th century, initial efforts were made to transform China's handicraft economy into a modern industrial system. This transformation was regarded, in fact, as a means of national survival. Thus the first steamship was built in 1862 and three years later a dock was established in Shanghai. In 1872 the China Merchants Steamship Navigation Company was organized and today it owns the largest mercantile fleet in China. The first railway was built between Woosung and Shanghai, a distance of about 12 miles, in 1876, and the first coal mine was exploited in North China in 1878. It was, however, not until the early years of the 90's that the first flour mill, the first cotton mill, and the first iron and steel works were established. These may be regarded as the beginning of the Chinese industrial revolution.

**China, with her vast unexploited natural resources and immense population still existing in a handicraft economy, offers one of the most fertile fields for industrialization in the world today. In spite of internal political strife which is hampering her development at present, Doctor Koo, Chinese ambassador to the United States and chief Chinese delegate to the United Nations, is confident that his country is well on the road to the economic stability which is necessary to attract foreign capital.**

## EFFECT OF WORLD WAR I

An impetus for industrial growth in China was furnished by the first World War when the scarcity of shipping facilities resulted in an almost complete paralysis of the import trade from Europe. Chinese industries had to manufacture goods not only for the domestic market but also for export to certain areas of Southeastern Asia. The result was that while there were not more than 600 factories using mechanical power in China in 1913, the number was nearly 2,000 by 1921. This trend of steady industrial expansion, however, encountered a great obstacle in the form of Japanese economic penetration and political encroachment. Certain industries were subjected to severe Japanese competition, notably textile manufactures.

Only with the recovery of her tariff autonomy in 1928, was China able to provide some degree of protection for her infant industries. Although Japanese occupation of Manchuria in 1931 deprived China of much of her mining industry, the Chinese met the challenge courageously by launching an ambitious program of economic reconstruction and industrial development in China proper. The upward trend of Chinese industrial expansion can be gauged from the development of the cotton textile industry which was the principal light industry of China. In the decade ending in 1933 the number of spindles in Chinese-owned mills increased by more than three times (from 888,000 to 2,885,786). Her cloth production nearly doubled (from 577 million square yards in 1930 to 991 million in 1935). The flour mills also enjoyed a considerable boom, having, in the several years preceding 1937, an annual output of from 60 to 90 million bags of wheat flour. An encouraging beginning also was made in the chemical industry. Of iron and steel manufacturers there was an increase of 625 machine shops and foundries in the years before the outbreak of the war. Although most of these were small and inadequately equipped, a fair number were able to produce a great variety of simple machinery such as generating motors, pumps, boilers, and machinery for textile, flour, vegetable oil, and tobacco industries.

Historians have observed that this rapid industrial progress was looked upon jealously by the Japanese and constituted an important factor in Japan's decision to invade China with a view first to the amputation of her northern provinces, which were well known for mineral deposits.

## WORLD WAR II LOSSES

China's part in World War II resulted in appalling industrial losses. In Shanghai alone the estimates of such losses range from $3,500 million to $4,400 million in Chinese national currency at prewar value. In the eastern section of the city some 900 factories and workshops normally employing over 30,000 workers were destroyed completely and more than 5,000 industrial

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establishments of varying sizes either were damaged or demolished.

These tremendous sacrifices did not dampen the spirit of resistance, however, but prompted the Chinese people instead to create a new industrial basis in the vast hinterland of China. By the end of 1940 more than 100,000 tons of machinery and other equipment had been removed from the coastal areas to the interior, not only to provide for the production of war materials, but also to lay a foundation for the development of the inland regions. In the war years considerable development was achieved in a number of industries, including spinning and weaving, metal, food production, chemical, and electrical industries.

## DOCTOR SUN'S PROGRAM

With the defeat of the enemy and the recovery of her lost territories, China is now on the threshold of another period of industrial development, the pattern of which was laid by Doctor Sun Yat-sen, the "Father of the Chinese Revolution," in his "International Development of China." His program included such principal items as the building of 100,000 miles of railways and one million miles of macadam roads; the development of three principal commercial harbors in north, central, and south China; the establishment of large cement works; the building of shipyards expected to have a yearly output of two million tons of vessels; and the mining of iron, coal, copper, and other minerals in sufficient quantities to meet the growing needs of Chinese industry.

In pursuance of Doctor Sun's economic testament for the purpose of accelerating and co-ordinating the herculean task of peacetime reconstruction, the Chinese Government recently established a Supreme Economic Council to give direction on all phases of economic development.

Three features of China's future industrial system will be:

1. Simultaneous development of both heavy and light industries: Prior to the war the main emphasis was focused on light industries, such as textile factories and flour mills, purely for the manufacture of consumption goods. Comparatively little capital was invested in iron and steel, machine tool, or chemical industries which produce capital goods.

But the recent war has taught the Chinese people a bitter lesson by demonstrating that without some heavy industries China neither could assure her national safety nor contribute to the maintenance of international peace

Chinese News Service photo

**Figure 1. Tin mines at the town of Kokui in China**

and security. There must be a more balanced development between heavy and light industries. While the industries for the production of consumption goods cannot be neglected, especially in these years immediately following the war when such goods have become so scarce in nearly all parts of the world, greater emphasis must be placed on the development of such fundamental or key industries as the electric power industry, and the metallurgical, machine tool, and chemical industries.

2. Regional development: Before World War II Chinese industries were confined to a few large cities along the coast and the Yangtze River. In Shanghai alone were located 42 per cent of China's 2,000-odd factories. With the concentration of industries in a few cities, one part of the country was modern while another part was backward; a part of the population enjoyed a comparatively high standard of living while people in other sections suffered dire poverty.

There must be, therefore, a more rational plan for future development, a geographically better distributed pattern of industrial production. It has been suggested that the vast extent of China should be divided into seven principal regions: the Northeastern Region including the whole of Manchuria; the North China Region including Tientsin, Peking, and Tsingtao as key cities; the Northwest Region with Sian, Lanchow, Tihwa, and so forth, as the centers; the East China Region including Shanghai and Nanking as chief cities; the Central China Region pivoting around Hankow and Wuchang; the South China Region with Canton, Kweiling, and so forth, as its centers; and the Southwest Region based upon Kunming, Chengtu, and Sichang. In each region careful investigations should be conducted to ascertain its human and natural resources so that industrial enterprises might be developed at points closest to the sources of raw material.

3. An industrial system based upon free enterprise but blended with government ownership in some industries: The Chinese Government favors a system of free enterprise with state controlled undertakings limited to certain categories, such as enterprises relating to national defense and enterprises requiring large-scale equipment which private interests are not in a position to undertake.

### OBJECT OF INDUSTRIALIZATION

The ultimate objective of industrialization is, of course, to raise the standard of living of the people and to increase their purchasing power. With the achievement of a higher living standard there naturally will be a greater demand for goods other than the bare necessities of life. In China today articles which are found in almost every American home, such as the telephone, the radio, the vacuum cleaner, and the refrigerator are considered great luxuries. With an increase in their purchasing power, the teeming millions of China will constitute an enormous market for such articles.

No program of industrialization in China can succeed, however, without large imports of capital goods such as steel rails, locomotives, bridges, ships, and mechanical equipment of all types. Almost every important industry in the country will need machinery and the United States is in the best position to supply it.

Industrial expansion in China offers great opportunity, not only for the importation of capital goods and technological skill from abroad, but also for direct foreign investments. The opening of the Chinese hinterland should be very similar to the epic story of the development of the "Golden West" in the history of the United States.

However, as a prerequisite for the orderly development of a program of industrialization settled conditions are necessary. Opportunity for economic and industrial co-operation must be accompanied by stability before it will attract foreign capital. This is natural but in a survey of the present Chinese situation one must not lose sight of its underlying meaning and significance. Thoughtful observers agree that China with all her apparent difficulties is striving to solve her problem of national unification.

This task has been complicated by the armed activities of an opposition political party, the Communist Party, which maintains an independent regime in one part of the country and challenges the authority of the central government. The government is conducting negotiations in the hope of bringing about a peaceful settlement but whatever happens, the task of national unification must be pressed forward until the unity of China is established firmly. The convocation of the National Assembly in Nanking for the adoption of a constitution, though the opposition parties have not attended, is indicative of the earnest and firm desire of the Government to bring about, as quickly as possible, the establishment of a constitutional democracy based upon the principle of representative government. Only when this indispensable condition for national unification is assured, can the plan for industrial development and other long range policies of reform and reconstruction be carried out successfully. This is the reason why I believe that the present situation in China, far from being a cause for discouragement, is really one which, leading to the achievement of unity and settled conditions, holds forth great promise for economic co-operation not only between the United States and China, but also between China and the rest of the world.

### NEED FOR FOREIGN CAPITAL

China's need of foreign capital for industrial development goes without saying. On more than one occasion, the Chinese Government has declared that foreign investment will be welcomed, whether it is in the form of loans, joint enterprises, extension of credits, or special investments.

Of course, in order to bring about economic co-

operation between any two countries, it is not enough for one side merely to express the desire to borrow. It is only natural for the other side to determine the terms upon which it will lend.

For this reason, the Chinese were not surprised by a recent public pronouncement as to the factors which the American authorities will take into consideration in

Chinese News Service photo

**Figure 2. Coolie method of transportation still employed at Central Radio Works near Kweilin, China**

*Plant, operated by National Resources Commission, manufactures all radio equipment used by the Chinese Army and government operated broadcasting stations in China*

determining whether or not to grant a government loan or to authorize a private loan to a foreign country. One of these factors will be the state of the national budget of the country concerned. In relation to China it was said that 80 per cent of the Chinese national budget was devoted to military expenses and this was considered excessive. The fact is that this large percentage for military expenditure was true only of the budget for 1945 when large-scale preparations still had to be provided for in the common effort to bring abut the defeat of the enemy. I am informed authoritatively by Doctor T. V. Soong, the Chinese Prime Minister, that only 60 per cent of this year's budget is devoted to military expenses, a reduction of 20 per cent from last year, and that the next year will see a further reduction of the same item. This is a signal improvement in the finances of the Chinese Government which cannot but produce a salutary effect upon the Chinese economic situation in general.

Reverting to the question of China's industrial development, I firmly believe that its importance cannot be overestimated. This industrial development will ameliorate at once the present condition of China's national economy, raise the standard of living of her people, and call for the importation of a great variety of machinery and other capital goods. One of the immediate results of this development will be an improvement in the processing of raw materials and an increase in the export of such properly processed products for the manufacturing industry in the United States. China's produce such as bristles, tungsten, antimony, tea, and wood oil will find a greater demand in the United States after they are well processed. This, in turn, will increase the purchasing power of the Chinese people and enable them to buy more from the United States.

This aspect of the Chinese industrial development should interest especially American engineers, manufacturers, and business people. If Chinese industry should adopt standard methods of processing and production, such as are in general application in the American industrial domain, the two countries could cooperate in the economic and industrial field to an extent beyond present expectation, and such extensive cooperation not only would profit their respective economies but would promote world trade.

## STANDARDS FOR PEACE

The American Standards Association seeks to promote the adoption of standards in the realm of industry and business. But the fundamental principle of standardization should be applicable in other fields of life and activity as well. If the peoples of the world could agree upon a common standard of conduct and practice, a great step will have been made toward the attainment of mutual understanding, mutual confidence, and universal peace. Only then will suspicion, distrust, friction, and conflict disappear among the nations of the world, for then there will be no longer any debate and controversy as to what is right, just, and decent.

The charter of the United Nations sets forth certain common principles and purposes for the member states to observe. But by the very nature of the international community as it is constituted at present, the standards of conduct thus established for the family of nations perforce are limited in their scope and application. If we hope to enjoy the blessings of enduring peace, we must try to make the ideal of one world a living reality with one standard of good and evil, of right and wrong, and of justice and injustice. May we of our generation and the generations to come all strive to bring about this very much desired end.

# Measurements in Communications

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**For convenient reference, some of the more common measurement units and scales used in communication engineering are presented in tabular form together with supplementary explanatory text. Included in the table, which also indicates the limitations involved, are quantities used in measuring power, volume, circuit noise, sound, light, radio fields, crosstalk coupling, and certain other transmission concepts.**

AN ENGINEER sometimes is required to review data from unfamiliar fields. These data often are expressed in units that are difficult to relate to those associated with his normal work. In communication engineering, the customary measurement units and scales are complicated by many physiological and psychological factors, because the human senses of hearing and sight are being dealt with. Furthermore, the communication power is not always flowing through circuits and equipment, but sometimes is propagated through air or space, as sound, light, and radio waves. Because of all these factors, there is no simple direct relationship between all the measurement units and scales used by communication engineers.

For well-known reasons, most of these scales are logarithmic in character. Standard practice requires a definition of the quantity to be measured, the calibration of the measuring equipment, and often a suitable reference base.

A tabulation of the most frequently used communication data, taken from telephonic, acoustic, and electronic fields, has been prepared for convenient reference, and some of the limitations in using the table have been indicated. (A family of curves could be plotted, but the restrictions in applying the data could not be indicated as easily as in tabular form.) As this article is intended only to describe this table briefly, it is not feasible to develop rigorously each subject involved, and so a partial list of references has been included for convenience.

The table does not include all of the communication units and scales currently or previously used. For example, telephone subscriber loop loss data expressed in decibels relative to a reference condition, telephone noise units, older type of volume indicator readings in "decibels" based upon various power and impedance calibrations, 6- and 12.5-milliwatt reference powers, telegraph transmission terms, light measurements under scotopic vision conditions, noise and distortion transmission impairments, signal-to-noise ratios, circuit merit, per cent modulation expressed in decibels, and television terms, are not tabulated or discussed. [Decibel equals ten times the logarithm (base 10) of the ratio of the output power to the input power.]

## Part I

### POWER

Column 1 lists some of the common units of electric circuit power tabulated in multiples of ten. This covers the range generally involved at the present time in communication engineering.

Column 2 lists electrical watts in powers of ten. This simplifies calculations and columns 1 and 2 are related directly to each other.

Column 3 expresses electric power in decibels[1] referred to the commonly used base of one milliwatt. The algebraic sign is required to indicate whether the specific power is greater or less than one milliwatt. In the Bell System, this unit generally is abbreviated "dbm" and for the sake of convenience this abbreviation will be used throughout this article. Thus, plus ten "dbm" means ten decibels above one milliwatt or ten milliwatts.

Previously, a value of six milliwatts was used widely as a reference power for steady state calibrations. The difference between the 1-milliwatt and 6-milliwatt bases is about 7.78 decibels, and power expressed in terms of the 6-milliwatt base can be converted roughly to "dbm" by adding eight decibels algebraically to the value.

Column 4 tabulates mechanical power in ergs per second. Column 4 is related directly to columns 1 to 3, inclusive. For example, one milliwatt is equal to: $10^{-3}$ watts, 0 "dbm," and $10^4$ ergs per second.

### QUANTITIES RELATED TO SPECIFIC POWER ONLY IN CALIBRATION

Columns 5, 7, and 8 include quantities related to specific amounts of power only in the calibration of the

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measuring equipment and they are not related directly to each other, or to other quantities in the table, except as noted in the following.

### VOLUME

Column 5 shows the readings of a standard volume indicator[2] calibrated in volume units, when bridged across a 600-ohm circuit in which 1,000-cycle sine wave power is flowing. The instrument is calibrated to read 0 when the power under these conditions is one milliwatt. Thus, although the volume indicator is marked in vu (expression of volume numerically equal to relative strength of the waves in question in decibels above or below reference volume), its readings under these conditions are actually power in decibels referred to one milliwatt.

Volume of speech or other program material measured with a standard volume indicator read in a specified manner (that is, representative maximum readings) is expressed in vu. Column 6 emphasizes the fact that volume is not related to specific amounts of power, because of the dynamic characteristics of the meter, the varying wave forms, and duration of the power. For example, on ordinary conversational speech from one type of subscriber's telephone set, the long time average power (rms) is roughly six decibels below the peak readings of the meter in vu, and the actual peak power may be 18 to 20 decibels above this average power. The meter is too slow to follow these peaks of power,[3,4] and too fast to indicate a long time average. Its dynamic characteristics are such that a maximum deflection is reached about 0.3 second following application of a constant-amplitude 1,000-cycle sine-wave tone.

Prior to standardizing volume indicators, there were several types of instruments in use which read volume in decibels above or below "reference volume." As these older volume indicators employed instruments with different dynamic characteristics and were calibrated in circuits of different impedances, and with different amounts of power, the new vu and the old decibel volume readings are not directly comparable.

### NOISE

Columns 7, 8, and 9 refer to measurements of circuit noise made with "noise measuring sets." These have various weighting networks to take into consideration, the response of different types of subscriber telephone sets or other terminal equipment, distortion of usual types of circuits, response of the human ear, and relative interfering effects of different noises on various classes of service.[5,6] Since at normal conversational sound levels the human ear fully appreciates the loudness of sounds in about 0.2 second, the integration time constant of the meter is about 0.2 second, so as to be approximately proportional to the response time of the ear.

Column 7 is the decibel reading obtained on steady 1,000-cycle sine-wave tone, the set being calibrated to read zero on one micromicrowatt of 1,000-cycle power, sometimes referred to as "reference noise." The values shown apply for "flat" weighting, weighting for program transmission circuits, and weighting for the older type of telephone sets.

Column 8 is the decibel reading obtained on steady 1,000-cycle tone with a noise measuring set modified to reflect more nearly the response obtained with the latest type of telephone sets, and adjusted so that equal noise meter readings obtained on telephone circuits with the old and new telephone set weighting networks mean equal interfering effects.

Telephone circuit noise readings often are referred to in decibels of noise adjusted to equal interfering effect. (Note: decibels of noise adjusted to equal interfering effect may be converted to approximate "noise units" by means of the current ratio corresponding to the number of decibels and taking zero decibels of noise adjusted to equal interfering effect as about seven noise units, for example, 20 decibels of noise adjusted to equal interfering effect (abbreviated 20 "dba") is about 70 noise units.)

Noise measurements are made by reading the noise meter in a specified manner, that is, representative maximum readings. Column 9 points out that noise readings do not represent specific amounts of circuit power because of various wave shapes and duration of noise, weighting networks employed, and so forth. However, in general, the meter reading is proportional to noise-weighted electric power. The most probable value of this power is equivalent to the sum of the weighted individual single frequency powers, or to the square root of the sum of the squares (rss) of the weighted single frequency rms current (or voltage) components of the complex noise. Measurements of noise always should be accompanied by a statement of the weighting used.

Acoustic noise and radio noise (the latter being measured with "radio-noise-meters")[7] are not discussed in this article, but acoustic noise will be mentioned under the heading "Sound." It might be mentioned that the smallest amount of power listed in the table of $10^{-16}$ watt ($-130$ "dbm") is approximately the rms noise power of thermal agitation at 80 degrees Fahrenheit over a band of frequencies 6,000 cycles wide located anywhere in the frequency spectrum. This represents one of the natural limits of amplification.[8] Various investigators report that this type of noise has a "peak factor" (ratio of peak to effective value) of roughly 12 to 13 decibels over the usual audio band widths and for normal time intervals.

## Part II

### QUANTITIES REQUIRING TRANSLATION FOR MEASUREMENT

Sound power flows through air somewhat as light and radio power flow through space. These quantities have

## Table I. Some Measurement Units and Scales Used in Communication Engineering

### Part I

| POWER | | | | QUANTITIES RELATED TO SPECIFIC AMOUNTS OF POWER ONLY IN THE CALIBRATION OF THE MEASURING EQUIPMENT | | | | |
|---|---|---|---|---|---|---|---|---|
| ELECTRICAL | | | MECHANICAL | VOLUME | | CIRCUIT NOISE | | |
| COMMON UNITS | WATTS IN POWERS OF TEN | IN DB REFERRED TO BASE OF ONE MILLIWATT | ERGS PER SEC | READING OF A STANDARD VOL IND CALIBRATED TO READ IN VU | | READING OF NOISE MEASURING SET IN DB ABOVE REFERENCE | | |
| | | DBM | | ON STEADY 1000~ POWER IN 600 OHM CIRCUIT | ON SPEECH AND MUSIC IN 600 OHM CIRCUIT | ON STEADY 1000~ SINE WAVE TONE: FLAT, PROG & OLD TEL SET WEIGHTING | ADJUSTED FOR NEW TEL SET WEIGHTING | ON RANDOM NOISE |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | | | | | REPRESENTATIVE MAXIMUM READINGS TAKEN AS MEASURE OF VOLUME IN VU NO FIXED RELATION TO SPECIFIC AMOUNTS OF POWER DUE TO DYNAMIC CHARACTERISTICS OF METER AND VARYING WAVE FORMS AVERAGE POWER MAY BE SEVERAL DB BELOW STEADY POWER FOR SAME READING | | | REPRESENTATIVE MAXIMUM READINGS TAKEN AS MEASURE OF NOISE IN DB ABOVE REFERENCE. NO FIXED RELATION TO SPECIFIC AMOUNTS OF POWER, DUE TO DYNAMIC CONSTANTS OF METER, VARYING WAVE FORMS, FREQUENCY COMPOSITION OF NOISE AND DIFFERENT WEIGHTINGS. HOWEVER THE READING IS GENERALLY PROPORTIONAL TO "NOISE-WEIGHTED POWER." TELEPHONE 'CIRCUIT NOISE IS EXPRESSED IN "DBA" |
| 100 K W. | $10^{5}$ | +80 | $10^{12}$ | WITH ATTENUATION +80 | | | | |
| 10 " | $10^{4}$ | +70 | $10^{11}$ | +70 | | | | |
| 1 " | $10^{3}$ | +60 | $10^{10}$ | +60 | | | | |
| 100 WATTS | $10^{2}$ | +50 | $10^{9}$ | +50 | | | | |
| 10 " | $10^{1}$ | +40 | $10^{8}$ | +40 | | | | |
| 1 " | $10^{0}$ | +30 | $10^{7}$ | +30 | | | | |
| 100 M.W | $10^{-1}$ | +20 | $10^{6}$ | +20 | | | | |
| 10 " | $10^{-2}$ | +10 | $10^{5}$ | +10 | | | | |
| 1 " | $10^{-3}$ | 0 | $10^{4}$ | 0 | | 90 | 85 | |
| 100 µ.W. | $10^{-4}$ | -10 | $10^{3}$ | -10 | | 80 | 75 | |
| 10 " | $10^{-5}$ | -20 | $10^{2}$ | -20 | | 70 | 65 | |
| 1 " | $10^{-6}$ | -30 | $10^{1}$ | WITH AMPLIFICATION -30 | | 60 | 55 | |
| .1 " | $10^{-7}$ | -40 | $10^{0}$ | -40 | | 50 | 45 | |
| .01 " | $10^{-8}$ | -50 | $10^{-1}$ | -50 | | 40 | 35 | |
| 001 " | $10^{-9}$ | -60 | $10^{-2}$ | -60 | | 30 | 25 | |
| 100 µµ.W. | $10^{-10}$ | -70 | $10^{-3}$ | -70 | | 20 | 15 | |
| 10 " | $10^{-11}$ | -80 | $10^{-4}$ | -80 | | 10 | 5 | |
| 1 " | $10^{-12}$ | -90 | $10^{-5}$ | -90 | | 0 | -5 | |
| .1 " | $10^{-13}$ | -100 | $10^{-6}$ | | | | | |
| .01 " | $10^{-14}$ | -110 | $10^{-7}$ | | | | | |
| .001 " | $10^{-15}$ | -120 | $10^{-8}$ | | | | | |
| .0001 " | $10^{-16}$ | -130 | $10^{-9}$ | | | | | |

### Part II

| COMMON UNITS | QUANTITIES REQUIRING TRANSLATION FROM ONE MEDIUM TO ANOTHER FOR MEASUREMENT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | SOUND | | | | LIGHT | | RADIO FIELD STRENGTH | | |
| | 1000 CYCLE FREE PROGRESSIVE WAVE IN AIR | | | RANDOM SOUND | 5550 ANGSTROM UNITS (PHOTOPIC VISION CONDITIONS) | | EQUIV POWER FLOW IN SPACE | VOLTAGE IN SPACE | |
| | EQUIV ACOUSTIC POWER FLOW IN WATTS PER $CM^2$ | ACOUSTIC PRESSURE IN DYNES PER SQ CM (BARS) | READING OF MEAS SET IN DB ABOVE REFERENCE | READING OF MEAS SET IN DB ABOVE REF | EQUIV POWER FLOW IN SPACE IN WATTS PER $CM^2$ | LUMENS PER SQUARE FOOT | WATTS PER SQUARE METER | MILLIVOLTS PER METER | EQUIV DB ABOVE REFERENCE OF 1 µV/M |
| 1 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| | | | | REPRESENTATIVE MAXIMUM READINGS TAKEN AS MEASURE OF SOUND IN DB ABOVE REFERENCE NO FIXED RELATION TO SPECIFIC AMOUNTS OF POWER DUE TO DYNAMIC CHARACTERISTICS OF METER, WEIGHTINGS, AND VARYING WAVE FORMS HOWEVER THE READING IS GENERALLY PROPORTIONAL TO "WEIGHTED SOUND PRESSURE LEVEL." | | | | | |
| 100 K W. | | | | | | | | | |
| 10 " | | | | | | | | | |
| 1 " | | | | | | | | | |
| 100 WATTS | | | | | | | | | |
| 10 " | | | | | | | | | |
| 1 " | | | | | | | | | |
| 100 M.W | | | | | | | $10^{-1}$ | 6140 | 136 |
| 10 " | | | | | $10^{-2}$ | 6039 | $10^{-2}$ | 1940 | 126 |
| 1 " | $10^{-3}$ | 630 | 130 | | $10^{-3}$ | 603.9 | $10^{-3}$ | 614 | 116 |
| 100 µ.W. | $10^{-4}$ | 200 | 120 | | $10^{-4}$ | 60.39 | $10^{-4}$ | 194 | 106 |
| 10 " | $10^{-5}$ | 63 | 110 | | $10^{-5}$ | 6.039 | $10^{-5}$ | 61.4 | 96 |
| 1 " | $10^{-6}$ | 20 | 100 | | $10^{-6}$ | .6039 | $10^{-6}$ | 19.4 | 86 |
| .1 " | $10^{-7}$ | 6.3 | 90 | | | | $10^{-7}$ | 6.14 | 76 |
| .01 " | $10^{-8}$ | 2.0 | 80 | | | | $10^{-8}$ | 1.94 | 66 |
| 001 " | $10^{-9}$ | .63 | 70 | | | | $10^{-9}$ | .614 | 56 |
| 100 µµ.W. | $10^{-10}$ | .20 | 60 | | | | $10^{-10}$ | .194 | 46 |
| 10 " | $10^{-11}$ | 063 | 50 | | | | $10^{-11}$ | 061 | 36 |
| 1 " | $10^{-12}$ | .020 | 40 | | | | $10^{-12}$ | .019 | 26 |
| .1 " | $10^{-13}$ | .006 | 30 | | | | $10^{-13}$ | .006 | 16 |
| .01 " | $10^{-14}$ | .002 | 20 | | | | $10^{-14}$ | .002 | 6 |
| .001 " | $10^{-15}$ | 0006 | 10 | | | | $10^{-15}$ | .0006 | -4 |
| .0001 " | $10^{-16}$ | 0002 | 0 | | | | $10^{-16}$ | .0002 | -14 |

### Part III

| COMMON UNITS | QUANTITIES HAVING NO RELATION TO SPECIFIC AMOUNTS OF POWER | | | | | |
|---|---|---|---|---|---|---|
| | CROSSTALK COUPLING | | | TRANS LOSS OR GAIN | TRANS LEVEL | EFFECTIVE TRANS. |
| | AS LOSS FROM DISTURBING TO DISTURBED CIRCUIT | AS CROSS-TALK UNITS EQUIV TO DB IN COLUMN 19 | AS DB ABOVE REFERENCE COUPLING | IN DB | IN DB | IN DB |
| | DB | CU | DBX | | | |
| 1 | 19 | 20 | 21 | 22 | 23 | 24 |
| | | | | TRANSMISSION LOSS OR GAIN THROUGH A CIRCUIT OR CIRCUIT ELEMENT IN DB IS EQUAL TO TEN TIMES THE LOGARITHM (BASE 10) OF THE OUTPUT POWER TO THE INPUT POWER | TRANSMISSION LEVEL AT ANY POINT IN A CIRCUIT IS EXPRESSED AS THE NUMBER OF DB BY WHICH POWER AT THAT POINT IS ABOVE (+) OR BELOW (-) THAT AT SOME OTHER POINT, (SUCH AS A LONG DISTANCE SWITCHBOARD) TAKEN AS A "ZERO LEVEL" REFERENCE POINT | EFFECTIVE TRANSMISSION PERFORMANCE OF A TELEPHONE CIRCUIT EXPRESSED IN DB. INCLUDES THE EFFECT OF CIRCUIT LOSSES, DISTORTION, CIRCUIT AND ROOM NOISE IMPAIRMENT AND SUBSET PERFORMANCE, INCLUDING ITS SIDE TONE THERE IS NO RELATION TO SPECIFIC AMOUNTS OF POWER |
| 100 K W. | | | | | | |
| 10 " | | | | | | |
| 1 " | | | | | | |
| 100 WATTS | | | | | | |
| 10 " | | | | | | |
| 1 " | | | | | | |
| 100 M.W | | | | | | |
| 10 " | | | | | | |
| 1 " | | | | | | |
| 100 µ.W. | | | | | | |
| 10 " | | | | | | |
| 1 " | 30 | 31600 | 60 | | | |
| .1 " | 40 | 10000 | 50 | | | |
| .01 " | 50 | 3160 | 40 | | | |
| 001 " | 60 | 1000 | 30 | | | |
| 100 µµ.W. | 70 | 316 | 20 | | | |
| 10 " | 80 | 100 | 10 | | | |
| 1 " | 90 | 31.6 | 0 | | | |
| .1 " | 100 | 10 | | | | |
| .01 " | 110 | 3.2 | | | | |
| .001 " | 120 | 1 | | | | |
| .0001 " | | | | | | |

to be translated by means of a transducer (such as a microphone, photoelectric cell, or antenna) from one medium to another for measurements. Sound power in air (mechanical power) usually is converted to electric power and measured. Light, which is electromagnetic power, is converted by means of a photoelectric cell or other suitable means to electric power and measured. Likewise, the strength of a radio field at some point is converted to electric circuit power and measured. The usual way of referring to power flowing through space is to measure its "intensity," that is, the flow of power through a unit area of wave front perpendicular to the direction of propagation. Since the acoustic impedance of air is about 41.5 ohms resistive, and the characteristic impedance of space to electromagnetic waves (light, heat, radio, and so forth) is 377 ohms resistive, a simple pressure or voltage reading per unit is a measure of the power intensity under a given set of conditions. Columns 10 through 18 represent quantities expressing this power intensity and requiring translation for measurement. Although these columns are not related to the other parts of the table, some of them are interrelated, as indicated.

### SOUND

Column 10 is the equivalent acoustic power flow, or "intensity," in watts per square centimeter of a 1,000-cycle free progressive sound wave in air.

Column 11 is the acoustic pressure in dynes per square centimeter (sometimes called "bars") corresponding to the power flow listed in column 10.

Column 12 is the reading in decibels of a "sound level meter" on steady 1,000-cycle sound.[9] The zero decibels reference point is a sound pressure of 0.0002 dyne per square centimeter at this frequency and this is about the same as the reference intensity of $10^{-16}$ watt per square centimeter. This is, roughly, the threshold of hearing for people with very sensitive ears.[4,10] If our ears were a few decibels more sensitive, we probably would hear the noise caused by thermal agitation of the air molecules. Sound levels above 130 decibels are "felt" rather than heard. Columns 10, 11, and 12 are related directly to each other.

Column 13 emphasizes that the reading of the sound level meter in decibels on random sound or acoustic noise is not related directly to specific amounts of power. This is the result of the dynamic characteristics of the meter, (that is, integration time constant of from 0.2 to 0.25 second to be proportional to the time response of the ear), the nature of the complex sound waves, and the fact that the meters have various weighting networks designated "40 decibels," "70 decibels," and "flat weighting," to allow for variation of the ear response with respect to frequency and sound level.[9,11] However, in general, the meter reading is proportioned to the weighted sound pressure level, that is, the square root of the sum of the squares of the weighted sound pressures of the single-frequency components of the complex sound. Sound level readings should be accompanied by a statement of the weighting used.

### LIGHT

Visible light consists of electromagnetic radiation or waves which are of such frequency as to affect the sense of sight. The human eye responds to about one octave, between the wave-length limits of 0.38 micron to 0.76 micron, or to use another common terminology, 3,800 angstroms to 7,600 angstroms.[12] (One angstrom is $10^{-10}$ meter and, therefore, these visible wave lengths correspond to 790 megamegacycles to 395 megamegacycles.) The human eye is most sensitive to the middle of this range, that is, 5,100 angstroms (green) to 5,550 angstroms (yellow green), depending upon whether vision conditions are, respectively, scotopic (low level illumination) or photopic (high level illumination).[13]

The flow of effective light energy is termed luminous flux, and is proportional at a given wave length to the product of the radiant flux and the luminosity factor. For a particular light or color, there is a definite relationship between the radiant power or flux, when this is sufficiently high, and the luminous flux, known as the "mechanical equivalent of light" for that flux. At the wave length of maximum luminosity under photopic vision conditions, that is, 5,550 angstroms, the "minimum mechanical equivalent of light" is 0.00154 watt per lumen or 650 lumens per watt.[12]

Column 14 shows the equivalent power flow in watts per square centimeter of yellow green light (5,550 angstroms) corresponding to maximum visibility under photopic vision conditions, that is, high level illumination.

Column 15 tabulates the values of the light flux of column 14 in lumens per square foot. These values may be converted to the usual "illumination units" (lux, phots, microphots, foot-candles, and so forth) or "brightness units" (lamberts, candles per square inch, and so forth) by means of the usual conversion factors.[13] (Note: 1 lumen per foot$^2$ = 10.764 lux = 1.0764 millilumen per centimeter$^2$ = 1.0764 milliphots = 1 foot-candle, and 1 lumen per foot$^2$ = 1.0764 millilamberts = 0.3183 candle per foot$^2$.) Light of other frequencies also can be evaluated if the radiant flux intensities and luminosity factors are known. Columns 14 and 15 are not related to any other columns in the table.

As mentioned previously, the human ear is sensitive to sound powers within a few decibels of those produced by thermal agitation,[10] and there is evidence that the human eye is sensitive to comparable amounts of light power.[14] However, light power under scotopic vision conditions is not included in the table.

### RADIO FIELD STRENGTH

Column 16 represents the intensity of a radio field in space and is the equivalent power flow in watts per square meter.

Column 17 is the voltage in space, measured in "millivolts per meter" of a radio wave having the intensity shown in column 16.

Column 18 is the equivalent field strength in decibels and arbitrary reference base of one microvolt per meter. (Column 18 is to the nearest decibel.) Columns 16, 17, and 18 are related directly. For example, the field at one mile from a vertical quarter wave antenna located over sea water and radiating 1 kw is about 194 millivolts per meter,[15] which represents a power flow of $10^{-4}$ watt per square meter at that point, or a field of approximately 106 decibels.

# Part III

## QUANTITIES HAVING NO RELATION TO SPECIFIC AMOUNTS OF POWER

Columns 19 through 24 list quantities having no relation to specific amounts of power or to the other scales previously discussed. The quantities in columns 19, 20, and 21, however, are interrelated as shown in the table.

### CROSSTALK COUPLING

Column 19 is the decibels coupling loss between two circuits, one called the "disturbing circuit" and the other the "disturbed circuit."[16]

Column 20 tabulates the "crosstalk units" (sometimes abbreviated "cu") equivalent to $10^6$ times the current ratio corresponding to the decibels coupling loss of column 19 (assuming equal circuit impedances).

Column 21 indicates coupling in terms of a measure of coupling in decibels above reference coupling. Reference coupling is defined as the coupling which would produce a reading of zero decibels of noise adjusted to equal interfering effect on a noise measuring set, such as the Bell System number 2 type, connected to the disturbed circuit, when a test tone of 90 decibels of noise adjusted to equal interfering effect (using the same weighting as that used on the disturbed circuit) is impressed on the disturbing circuit at some specified transmission level point. Coupling in terms of a measure of coupling in decibels above reference coupling (usually abbreviated "dbx") is numerically equal to 90 minus the crosstalk coupling loss shown in column 19.

### TRANSMISSION LOSS OR GAIN

Column 22 is the transmission loss or gain through a circuit or circuit element expressed in decibels. Although expressed in decibels, similar to the other scales, there is no relationship to these scales nor to specific amounts of power. Decibel is merely the power ratio in this column.

### TRANSMISSION LEVEL

Column 23 is the transmission level in "plus or minus decibels" at any point in a circuit with respect to some reference point in the circuit.[17] For example, the transmitting long-distance switchboard is taken as the zero level reference point of a toll circuit. This usage is independent of any specific amount of power applied at this point, and column 23 has no relation to any other column in the table.

### EFFECTIVE TRANSMISSION

Column 24 refers to "effective transmission," a term used in the Bell System as an index to the transmission performance of a telephone connection, with the subscribers using it in the normal manner.[18] Effective transmission is expressed in decibels relative to a working reference telephone system, which is typical of commercial connections. It takes into account the combined effect upon the over-all transmission performance, of the circuit losses, the various types of distortion, circuit and room noise impairments, and relative subscriber set performance, including its side tone characteristics, that is, the direct transmission from transmitter to receiver of the same set. Although effective transmission is expressed in decibels, it has no direct relation to any specific amount of power and this column is not related to any other column in the table.

### CONCLUSION

The author hopes that the partial tabulation of communication data will serve as a convenient reference for engineers, and that the text will help to explain some of the limitations in using the units and measurement scales. No originality is claimed for any of the data. Acknowledgment is made for the contributions of those whose articles are contained in the partial list of references, and to many fellow workers in the Bell System.

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# Development of the Missouri Basin

B. H. GREENE

**The Pick-Sloan plan, as basis for the proposed development of the Missouri Basin, is described as intended to provide for the generation of hydroelectric power as well as flood control and irrigation. The development of so-called potential hydroelectric power sites is stated to depend upon factors such as essential need and estimated cost, but in general the author believes that the intrinsic value to the government of the power itself will exceed greatly the value of the revenue from its sale. Costs are not discussed.**

THE PICK-SLOAN PLAN, which constitutes the bulk of the proposed development of the Missouri Basin, is a combination of the original plan of Lewis A. Pick, major general, United States Engineer Corps of the War Department, which is fundamentally a flood control plan with allied benefits, and the original plan by W. G. Sloan, assistant regional director, Bureau of Reclamation, United States Department of the Interior, calling principally for irrigation with allied benefits. One of the allied benefits of each plan is the generation of hydroelectric power.

The two agencies involved have definite and separate responsibilities which are harmonized by close collaboration in the consolidated plan. The Federal Power Commission in its examination of the various plans and projects necessarily exerts an additional co-ordinating influence. The studies relating to power development possibilities can recognize only a unified plan intended to yield the maximum production of hydroelectric power consistent with the primary purposes of flood control, irrigation, navigation, and consumption uses of water.

Essential substance of a paper presented at the Midwest Power Conference, Chicago, Ill., April 4, 1946.

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All figures given in this article have been derived from various studies of the Missouri Basin which have been made by the United States Engineer Corps, the Bureau of Reclamation, and the Federal Power Commission. However, because refinements of the general plan are being worked out, these figures must be regarded as approximate rather than final.

The Pick-Sloan plan does not embrace all of the potential hydroelectric power sites in the basin, but does provide for the development of approximately 1,500,000 kw. Additional potential hydroelectric power sites in the Missouri Basin bring the basin's total potential power to about 5,000,000 kw, with average annual generation of 25 billion kilowatt-hours. How much of this can be developed economically has not been determined as yet.

## BASIS FOR DEVELOPMENT

The probability of the development of so-called potential hydroelectric power depends upon a number of factors, including essential need, cost of development, and desirability from various angles. One example of a potential power source is the main stem of the Missouri River from Gavins Point on down to its mouth. In this reach there is a fall of about 700 feet and a potential possibility of from 10 to 15 billion kilowatt-hours per year. The eventual development of all or part of this is, of course, problematical; but it is important that the possibility of its realization be kept in mind, especially in the Federal Power Commission's recurrent appraisals of power possibilities and probabilities.

The development of an area as vast as the Missouri Basin is naturally of great interest to a large number of people and to various agencies, both public and private. Both the War Department and the Department of the

Interior are interested because of the projects which they are planning, respectively, to build. The Department of Agriculture is interested because of the benefits to agriculture in general which will accrue from the valley development. The Federal Power Commission has a very extensive interest in all phases of the proposed plans for a number of reasons.

Under the provisions of the Federal Power Act the commission is authorized to investigate possible utilization of the water power resources of any region to be developed, as well as the relationship of the water power industry to other industries and to interstate or foreign commerce. These investigations also may concern the location, capacity, development costs, and relation of power sites to markets. The licensing of water power projects by the commission also must be given consideration upon the basis of feasibility, marketability of their potential power supply, the programming of power installations.

### TWO ASPECTS TO UTILIZATION

There are two predominant aspects of the approach to the full utilization of a region's resources and these two aspects must be co-ordinated. The first is the engineering aspect in which the immediate objective is the design and construction of projects which will assure the maximum recovery of water resource values with the minimum expenditure of cost and effort. The second is the economic aspect, in which the distribution of irrigation water, electric power, and other benefits offered by the projects, is placed on a cost basis which will assure maximum utilization. The Federal Power Commission's policy with respect to water resources, and more particularly hydroelectric power, embodies this dual approach. The development of power, as thus conceived, is not an end in itself, but is a means to an end. This approach recognizes the fact that power is valuable as it is freely utilized; that utilization is limited unless rates are at the lowest possible level; and that low cost power in abundance will create its own market and in so doing will provide a major stimulus to the expansion of the regional economy and to a fuller life for the entire community. By taking this broader viewpoint of basin development, and by mutual considerations and planning with many other local, state, and federal agencies, the commission is helping to build the regional economies which probably will constitute future American civilization. The soundness of these economies will be a prime factor in the stability and permanence of the United States in the postwar world.

### CO-ORDINATING AGENCY

To co-ordinate generally the work at field level of the several agencies involved, the Federal Inter-Agency River Basin Committee established the Missouri Basin Inter-Agency Committee in March of 1945. This latter committee is composed of one member each from the War Department, Department of Interior, Department of Agriculture, and Federal Power Commission. Four representatives have been selected by the governors of the ten affected states to sit with the committee in its regular meetings. This committee functions in the general planning and co-ordination to produce results satisfactory to the states and Federal agencies concerned.

Ten states in all; Montana, Wyoming, Colorado, North and South Dakota, Nebraska, Kansas, Minnesota, Iowa, and Missouri; are included, either totally or partially, in the Missouri Basin which, with an area of 529,350 square miles, represents one sixth of the area of the United States. The region is favored with enormous mineral resources (including large supplies of coal hundreds of thousands of square miles of agricultural and stock-raising land, and a healthful climate). Its accelerated development should be an important factor in the betterment of the national economy of the United States at this time.

The Missouri River itself is 2,476 miles in length, with the Yellowstone, Niobrara, Platte, Kansas, and Osage as its principal tributaries.

Unquestionably, in order to increase irrigation, to control floods as much as is reasonably possible, and to provide ample channel facilities, something considerably more must be done than simply the building of dikes and the usage of natural valley storage in the Missouri Basin. Large total reservoir capacity must be provided by the construction of dams at suitable points in the basin. In the present planning, about 100 eventual reservoirs are contemplated with more than 100 million acre-feet of storage. Some of the many reservoirs will be small, but it is planned to install power equipment in all of those where it is found that it will be economically feasible.

The storage of water for irrigation, flood control, or navigation invites the installation of power equipment to utilize the head developed by such reservoirs and it would be a waste of natural resources to neglect the development of power, wherever possible, in a stream regulated for other purposes. The development of this power is by no means a minor matter as is evidenced by plans for installation of 105,000 kw at Fort Peck, 320,000 kw at Garrison, 400,000 kw at Oahe, and 240,000 kw at Fort Randall. It should be emphasized that the proposed hydroelectric power development in the basin, while not the primary objective of the over-all plan, is of real and important value to the region and will be included in all reservoir projects insofar as is feasible consistent with the paramount uses of water in the Missouri Basin.

The relationship between the various planned reservoirs is somewhat complex and is not easy to describe. Each reservoir usually will have several functions such as storage for irrigation, flood control, navigation, desilting, reregulation, power, releases for water supply, sanitation, recreation, or some combination of these pur-


**Figure 1. Proposed Missouri River Basin reservoir projects of the United States War Department and Department of the Interior at which power development appears feasible**

poses. Thus, this type of reservoir can be called, appropriately, a multipurpose reservoir.

## CO-ORDINATION OF RESERVOIR OPERATION

Co-ordination of operation of the larger reservoirs seems to be definitely a beneficial part of the basin plan, and co-ordination of as many of the smaller ones as is possible and effective will be worked out. This co-ordination will center around storage and releases at each reservoir over both long and short periods; that is over periods varying from perhaps several years to periods as short as a few days or weeks. In those reservoirs where power is involved, its production necessarily will be an important consideration in setting up the plan of co-ordinated operation of all affected reservoirs.

The need for co-ordination of reservoir operation, from the power viewpoint, is very important on that part of the Missouri River between the Fort Peck Dam and Yankton, S. Dak. In this 1,030-mile stretch, which contains the Fort Peck Reservoir, the Pick-Sloan plan contemplates the construction of three large storage reservoirs and power plants, Garrison, Oahe, and Fort Randall, and also power plants at Big Bend and Gavins Point.

The Fort Randall–Gavins Point project is illustrative of one of the problems involved in co-ordinating the operation of a system of reservoirs. This project will consist of a large reservoir at Fort Randall and a relatively small reregulating reservoir immediately downstream at Gavins Point, with a power plant at each site. The upper portion of the Fort Randall reservoir, about 2,350,000 acre-feet, is planned for flood control. The remainder of its storage will be divided between 2,450,000 acre-feet for conservation to regulate the stream flow in the interest of navigation, power, pollution abatement, and water supply for sundry uses, and about 1,400,000 acre-feet for dead storage. The Gavins Point dam and reservoir will reregulate the releases from Fort Randall and will provide head for generation of hydroelectric power.

The operation of the Fort Randall reservoir will be based primarily upon flood control, navigation, pollution abatement, and other conservation requirements, which, with Gavins Point reregulation below, are determinative of the characteristics of the power generation at both projects. Large stream flows in the magnitude of about 20,000 cubic feet per second or more will be required during the 8-month navigation season and small flows during the 4-month winter season. The flows during the winter season will be the minimum necessary to hold stream pollution within desired limits and to provide adequate water for riparian users and

will be in the order of 4,000 to 5,000 cubic feet per second. Thus, navigation season flows will be four to six times as large as winter flows.

These plans for the release of water result in marked differences, of course, in the monthly amount of energy which can be generated in the two seasons. Monthly generation during the winter season will be in the order of 20 million kilowatt-hours while that during the navigation season may be as little as 50 million kilowatt-hours in adverse years and as much as 200 million kilowatt-hours in good water years.

### DETERMINING CONDITIONS

The ultimate installation at the Fort Randall plant is determined by one of two conditions, whichever results in the larger capacity. Insofar as winter operation is concerned, it is determined by the load factor at which the winter energy can be utilized on the future regional curve, under minimum head conditions. From the standpoint of navigation season operation, the installation must be adequate also to provide sufficient capacity to utilize the regulated stream flow during adverse and average water years without undue waste. Under neither condition will it be desirable to operate Fort Randall purely on base loads, if its full value for capacity is to be realized. This means that there will be wide fluctuations in turbine discharges in both seasons.

Violent fluctuations in stream flow at Yankton, S. Dak., downstream from the Fort Randall and Gavins Point sites, are objectionable during the summer months from the standpoint of navigation and during the winter because of ice jams, accelerated bank erosion, sanitation requirements, and the general inconvenience accompanying violent changes in stage. For these reasons the Fort Randall plant could not be operated for peaking purposes, except for the Gavins Point reregulating reservoir below it. It follows then that Gavins Point must be operated as a base load plant.

Inasmuch as the releases from Gavins Point must be as uniform as possible, sufficient pondage must be provided there to smooth out the fluctuating releases from Fort Randall when that plant is operated for peaking purposes in either the navigation or winter season. Furthermore, it is not only necessary to provide sufficient pondage to reregulate the fluctuating flows required to meet daily load peaks, but what is more important, sufficient pondage must be provided to permit closing down Fort Randall during week ends when the regional load may not require its operation. About 100,000 acre-feet of active storage capacity will be needed at Gavins Point for week-end pondage, this amount being determined by the requirements of the navigation season.

Upon consideration of the long sustained dry period between 1930 and 1942, and the probable future demands of irrigation, navigation, and sanitation during such periods, it can be seen that a high degree of co-ordination of reservoir operations will be required to satisfy primary demands and also to obtain optimum power production during periods of low natural flow. The releases from each reservoir during these periods should be co-ordinated so well that all of the water passing through each dam will go through the turbines and develop firm power. However, although a plan of co-ordinated operation of all storage reservoirs is of utmost importance for satisfactory results, the best laid plans of operation have to be changed from time to time as changing circumstances dictate. It well can be said that the operation technique always will be subject to improvement, and the operating plan never will become permanent in its details.

Many of the projects under discussion, such as the proposed transmountain diversions of water into the Missouri Basin by the Colorado–Big Thompson and the Blue River–South Platte projects in Colorado, have aspects which are of special interest. Both are designed to provide more water for eastern Colorado, primarily for irrigation purposes. The Colorado–Big Thompson diversion of Colorado River waters from the western side of the continental divide at Grand Lake through a $13^1/_2$-mile tunnel, already completed, to Estes Park on the eastern slope, provides water at the latter point at a high altitude. Advantage is taken of this condition to generate hydroelectric power at "power drops" on its way to the main irrigation system in northeastern Colorado. The total installed capacity planned is 165,000 kw.

The Blue River–South Platte project will take water in a similar manner from the western slope of the divide and deliver it to the South Platte River system for utilization in irrigation and domestic water supply. This project likewise will take advantage of the high altitude of initial delivery on the eastern slope of the mountains to generate power. A considerable portion of the power produced by these two diversion projects will be utilized for water pumping in the irrigated areas.

### TYPICAL PROBLEMS

Typical of some of the problems being met are those in connection with the Boysen project, located 20 miles south of Thermopolis, Wyo., on the Big Horn River. The dam and reservoir which have been planned will require the relocation of the Chicago, Burlington, and Quincy Railroad at that point and also of United States highway 20. The railroad relocation, as planned at present, requires the driving of two tunnels through rock for the railroad, the largest to be more than 7,000 feet in length, and the construction of a railroad bridge approximately 200 feet long. In addition to the ventilation problems of the tunnels, it is desirable also to guard against a fault condition at that point. The total cost of right of way for this project may exceed the cost of the dam and power plant. However, while the power to be generated is only about 15,000 kw, Boysen Reservoir functions in flood control, storage for irrigation, and desilting, in addition to its production of power, and its

cost can be justified easily by the total benefits derived.

From the standpoint of physical size and power output, the Garrison project in North Dakota is a good example. This is a main stem project and the usual valley characteristics of the Missouri River require a dam at this point with a crest length of 12,000 feet. Its height above the natural valley floor is planned to be 210 feet. It will be an earth-fill dam of about 75,000,000 cubic yards bearing some resemblance to the Fort Peck Dam. A co-ordination study which has been made indicates that this reservoir with a gross storage capacity of 24,500,000 acre-feet will a have a tentative 5,750,000 acre-feet for flood control, 13,850,000 acre-feet for multipurpose, and 4,900,000 acre-feet for dead storage. Construction considerations appear to require eight 24-foot diameter diversion conduits during the closure period of the dam. Two of these conduits will be steel-lined, and initial provision for power development will include surge tanks, a building for generating units, a step-up transformer station with necessary switching, and complete control equipment. The initial building will be constructed for four units, and the remainder of the structure for the additional four units will be built at a later date. When complete, the station under this plan will have eight 40,000-kw units.

The Oahe Dam, also an earth-fill dam, is planned to be about 7,800 feet long with a probable height of 223 feet above the valley floor. Total storage will approximate 19,600,000 acre-feet, and, with a possible installation of 400,000 kw, the plan of construction probably will follow that of Garrison.

### FORT RANDALL RESERVOIR

The other large main stem reservoir is Fort Randall, with a planned earth-fill dam 10,000 feet in length by 170 feet high, storage capacity of 6,200,000 acre-feet, and a possible power installation of 240,000 kw.

The other main stem projects, Big Bend with a possible 120,000 kw and Gavins Point with probably 10,000 kw, will follow the general design and construction procedures as the larger plants. The Big Bend plant takes advantage of a large loop, 21 miles in length, in the river. At the beginning and end of this loop the river channels are about two miles apart. A power water canal across this interval will produce a head which will permit the generation of power. Big Bend is definitely a project to develop more power and will not be necessary until the growth of power load calls for it.

The Gavins Point project differs from Big Bend in one aspect with regard to power: It makes possible low load factor peaking operation at Fort Randall. In addition to this, it is a power producer in its own right.

With the development of the proposed main stem and tributary plants, under adverse stream flow conditions the plants on the main stem, including Canyon Ferry, Portage, Fort Peck, Garrison, Oahe, Big Bend, Fort Randall, and Gavins Point will produce about $3^1/_4$ billion kilowatt-hours per year. Of this amount, from a quarter to a third of a billion kilowatt-hours will be required for irrigation pumping. The tributary plants will produce, under adverse stream flow conditions, about 1,600,000,000 kilowatt-hours per year over and above irrigation pumping requirements.

Under average stream flow conditions, the main stem plants will produce about 6 billion kilowatt-hours and, with the tributary plants, more than 8 billion kilowatt-hours will be produced. The total installed capacity of the main stem and tributary plants ultimately will be about 1,600,000 kw.

The foregoing figures do not include the diversion projects in Colorado known as the Colorado–Big Thompson and Blue River–South Platte projects. Although these plants will be located within the Missouri Basin, they were not reported originally as part of the Missouri Basin developments because they are diversions of water from the Colorado River Basin. Based upon preliminary studies, the Colorado–Big Thompson is expected to have an installed capacity of 165,000 kw and an annual energy production of 630,000,000 kilowatt-hours. Similarly, the Blue River–South Platte project is expected to have an installed capacity of approximately 400,000 kw and an average annual generation of approximately 1,560,000,000 kilowatt-hours.

The addition of these two diversion projects will bring the total output of proposed plants within the Missouri Basin to well over 10 billion kilowatt-hours, in an average water year, with a total installed capacity of about 2,200,000 kw.

### DISPOSITION OF THE POWER

At this point the question naturally arises as to what disposition will be made of this new supply of hydroelectric power. Part of the answer is contained in Public Law 534:[1]

> Electric power and energy generated at reservoir projects under the control of the War Department and in the opinion of the Secretary of War not required in the operation of such projects shall be delivered to the Secretary of the Interior, who shall transmit and dispose of such power and energy in such manner as to encourage the most widespread use thereof at the lowest possible rates to consumers consistent with sound business principles, the rate schedules to become effective upon confirmation and approval by the Federal Power Commission.

And with reference to the transmission of such power, from the same source:

> The Secretary of the Interior is authorized from funds to be appropriated by the Congress, to construct or acquire, by purchase or other agreement, only such transmission lines and related facilities as may be necessary in order to make the power and energy generated at said projects available in wholesale quantities for sale on fair and reasonable terms and conditions to facilities owned by the Federal Government, public bodies, co-operatives, and privately owned companies. All moneys received from such sales shall be deposited in the Treasury of the United States as miscellaneous receipts.

The total program of construction of the various reservoirs and power plants will extend over a considerable period of years. Because of this, and also because of location, each power plant will encounter its own peculiar set of conditions in the disposal of its available power. For instance, the Kortes project in southern Wyoming will find a reasonably ready market for its output because of its proximity to an existing transmission system in need of additional power supply. The Garrison project in North Dakota, on the other hand, will start production with probably two 40,000-kw units, the remainder of its total 320,000 kw to be added in future years, as load conditions warrant.

## GENERAL OBJECTIVES

It is not possible, at present, to give a schedule for completion of the various projects in order to illustrate the over-all plan of power production and disposal. However, the general objectives can be stated. To secure a maximum of benefits from these new hydroelectric power sources, it will be necessary to interconnect the proposed plants to permit co-ordination between these plants and existing facilities in the region to which appropriate tie lines can be constructed. In addition, such supplementary lines will be constructed as may be necessary to transmit and dispose of the power in such manner as to encourage its most widespread use at the lowest possible rates to consumers.

The addition of this supply of hydroelectric power to the Missouri Basin is certain to have profound and far-reaching effects. Within a period of a relatively few years there will be a marked increase in the usage of electricity in new industries, existing industrial and commercial activities, and on farms and in homes. This will occur by reason of extension of transmission and distribution facilities and by lower rates permitted by low cost hydroelectric power.

It will occur also because the Missouri Basin is still a comparatively young and undeveloped part of the United States with a variety of natural resources. This factor is conducive to a rapidly growing population provided there are sufficient occupational opportunities. Already many industries and smaller manufacturing plants have found it to their interest to be located in Minnesota, Iowa, Missouri, Kansas, and Nebraska. As American industry and commerce grows, a goodly share of that growth is spreading steadily into the Missouri Basin. Large supplies of low cost electric power in the basin most certainly will accelerate the development of agriculture, industry, and commerce, with a corresponding increase in gainful occupations and, consequently, an increase in population and general improvement in living conditions. The development of potential projects in addition to those now planned may make available double the amount of electric power and vastly increase the benefits.

In other words, the hydroelectric power which will be derived from this basin development is intrinsically worth many times the revenue which the government will receive each year from its sale.

## ECONOMIC EFFECTS

To understand fully the significance and value of this new source of electric energy one must consider its total effect upon the economy of the Missouri Basin. Ordinarily one thinks of this in terms of immediate benefits such as greater availability of electricity at lower cost to homes and farms and the resulting improvement in living conditions, or lower cost power for development of new industries or expansion of older ones. Actually this is true, but it does not provide a conception of magnitude. To gain some idea of the size of the possible effects of this new source of power on the Missouri Basin, one may consider that every 75,000 kw of new power capacity, in addition to providing electricity for homes and farms, may be expected to bring about an investment of $50,000,000 in new industrial plants providing direct employment for some 7,500 additional workers. On this basis approximately $1^3/_4$ million kw of new capacity, not required for irrigation pumping, would result in an investment approaching a billion dollars in industrial plants.

This increased industrial development, together with the new direct and indirect trade and service agencies which it will bring about, may be expected to create new employment opportunities which should support an additional total population of about three quarters of a million people including the families of those employed.

The irrigation of additional lands will increase agricultural opportunities, and the availability of local adjacent markets resulting from increased activity will help in the development of agriculture. The balanced regional economy which results should benefit not only the basin but the United States as a whole.

It is interesting to note at this point that not only do regions contribute to national welfare, but they frequently benefit each other. An instance of this is the effect upon the Missouri Basin of the Saint Lawrence River navigation and power project. This latter project will move the entire western area hundreds of miles closer to the Atlantic Ocean, and will work hand in hand with the Missouri Basin development of irrigation, navigation, and power.

There seem to be many reasons why the progress of the United States, as well as the rest of the civilized world, depends upon electric power in plentiful quantities. Most certainly hydroelectric power developed in the Missouri Basin will contribute its quota of benefits to the basin and so will contribute to a better world.

## REFERENCE

1. Public Law 534, chapter 665, section 5. 78th United States Congress, second session.

# Engineering Organization in Canada

F. L. LAWTON
MEMBER AIEE

**During the past 50 years the development of professional and technical organizations has progressed steadily in Canada, as have movements to attain professional recognition for the engineer. Because of the current general interest in the subject of engineering professional organization, this descriptive review of Canadian developments in that field has been prepared by the AIEE vice-president for the Canadian District.**

THE LAST half century has seen a steady growth of the engineering and scientific professions in Canada, closely paralleled by the development of technical and professional bodies organized for the dissemination of technical information and interchange of professional experience, in order to supplement preprofessional training. Associated with such growth of the technical societies have been movements seeking to establish recognition of the profession, through legislative action, in order to secure public recognition of the engineer's status as a qualified practitioner and to assure the public of qualified professional service.

The Canadian Society of Civil Engineers, organized in 1887, was the first voluntary engineering society in Canada. As specialization in the engineering profession grew, this organization became the Engineering Institute of Canada. Its primary objective is "to facilitate the acquirement and interchange of professional knowledge among its members, to promote their professional interests, to encourage original research, to develop and maintain high standards in the engineering profession, and to enhance the usefulness of the profession to the public."

The Canadian Institute of Mining and Metallurgy was organized in 1898. In 1902 The Society of Chemical Industry of Great Britain founded a Canadian section. The Canadian Institute of Chemistry received its charter in 1921, and the Canadian Chemical Association began functioning in 1926. These three societies in the chemical field now constitute The Chemical Institute of Canada.

Interchange of engineering and scientific knowledge recognizes few boundaries. Canada District 10 of the AIEE was initiated with the formation of the Toronto Section in 1903. Also actively functioning and doing very useful work in Canada are the Canadian Council of the Institute of Radio Engineers, the Illuminating Engineering Society, American Society of Mechanical Engineers, and several others, with their various branches and chapters.

These developments in the engineering field have been followed by a corresponding growth of related professional associations. In 1890 the architects in Quebec and Ontario formed provincial professional associations, as did those in Alberta in 1906, in Saskatchewan in 1912, in Manitoba in 1913, in Nova Scotia in 1932, and in New Brunswick in 1933. The Royal Architectural Institute of Canada was chartered in 1907. It serves the technical and professional interests of architects and publishes an excellent technical journal, as do the Engineering Institute of Canada and the Canadian Institute of Mining and Metallurgy.

Land surveyors in Canada were conscious of the need of association for betterment of their technical and professional interests at an early date, organizing in Manitoba in 1874, in Quebec in 1882, in Ontario in 1886, in British Columbia in 1890, and in Saskatchewan in 1910. From a recognition of their dominion-wide solidarity the Dominion Land Surveyors Association was organized in 1882, from which sprang the Canadian Institute of Surveying in 1934. This organization publishes a technical journal.

## THE PROVINCIAL ASSOCIATIONS

Agitation and organization for attainment of proper legal recognition and policing of the profession to ensure competent practitioners, under the leadership of the Engineering Institute of Canada, led to the formation of Provincial Associations of Professional Engineers. Quebec led the way in 1898 with its Civil Engineers Act from which stems the Corporation of Professional Engineers. Nova Scotia, New Brunswick, Manitoba, Alberta, and British Columbia followed in 1920 and Ontario in 1922. At present, provincial legislation in eight of the nine provinces of Canada places control of the practice of engineering in the hands of the Provincial Associations of Professional Engineers.

Attainment of unity in as widely diversified a profession as that of engineering is a thing of slow and delicate growth. Although sponsored by the Engineering Institute of Canada, and having an identity of objective in the field of professional interests, the beginning of full co-operation between the Provincial

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The author wishes to thank W. P. Dobson (F '43) of the Hydro-Electric Power Commission of Ontario, Toronto, Canada, for furnishing much of the background material for this article.

Professional Associations and the Engineering Institute of Canada did not eventuate until the late 30's, when the first co-operative agreement was reached, that of 1938 with the Association of Professional Engineers of Saskatchewan. Nova Scotia followed in 1939, Alberta in 1940, New Brunswick in 1941, and Quebec in 1944. These agreements provide for joint membership, simplification of dues arrangements, and other co-operative endeavors.

Co-ordination of the activities of the Provincial Professional Associations was sought for many years, and was attained in 1936 through the formation of the Dominion Council of Professional Engineers. At this point it is well to note that the Dominion Council consists of eight representatives, one appointed by each Provincial Association. It is the co-ordinating medium and the national mouthpiece of the profession, its objectives being:

(*a*). Creation of a body representative of the Provincial Associations.

(*b*). The recognition of provincial autonomy.

(*c*). Co-ordination of all activities of the Provincial Associations throughout Canada.

(*d*). Active co-operation with other bodies toward the consolidation of the engineering profession in Canada.

These objectives are attained by:

(*a*). Assisting in securing approved legislation for the better protection and regulation of local professional interests.

(*b*). Securing the adoption of uniform standards of examination and membership.

(*c*). Arranging for reciprocal privileges between the Provincial Associations for the benefit of their members.

(*d*). Securing harmony of action in all matters affecting the common interest, and generally acting in an advisory co-ordinating capacity.

(*e*). Negotiating with other organizations for the advancement of the interests of the engineering profession.

In line with these objectives, the Dominion Council of Professional Engineers in 1941 initiated discussions between various groups and societies of the engineering and scientific professions. Following extended discussion, a conference was held in Montreal, in December 1943, which was attended by representatives of the national engineering societies, the Royal Architectural Institute of Canada, several of the provincial engineering and architectural associations, and the Canadian districts of American engineering societies. A resolution was adopted favoring the formation of an organization which could speak for all the participating bodies in matters of common national interest. Also, a constitution for such a body was prepared and circulated.

In 1944, engineers and scientists throughout Canada were confronted without warning by Order-In-Council *PC-1003*, containing the "Wartime Labour Relations Regulations," and making many of them subject to collective bargaining procedures. Deliberations on collective bargaining were held for the next year or so by representatives from 14 societies, through the medium of a committee, subsequently known as the Committee of Fourteen, which presented the views of engineers and scientists to the government through the minister of labor. Although a considerable measure of success was achieved, professional engineers and scientists suffered a handicap in establishing their right under this legislation because they had not been organized and were not in a position to make their views known promptly before the order-in-council was published.

Because the Committee of Fourteen had demonstrated that the various professional and scientific societies were capable of working together in the common interest, and because experience with respect to *PC-1003* definitely had demonstrated the desirability of establishing some permanent agency through which joint effort could be organized rapidly whenever necessary, the Canadian Council of Professional Engineers and Scientists was created and functions of the Committee of Fourteen absorbed by it with the approval of all but one of the national organizations represented on the Committee of Fourteen. The abstaining organization was the Engineering Institute of Canada.

The first meeting of the Canadian Council of Professional Engineers and Scientists was held in January 1945. At this meeting the following statement of aims, objectives, and operating procedure was adopted:

1. The council shall consist of one representative appointed by each of the participating societies, these representatives to be chief officers, and/or alternates appointed by them, of the participating societies.

2. The council welcomes the participation of other national professional engineering and scientific societies.

3. The field of activity of the council shall be as follows:

(*a*). The council shall deal with matters which are national in scope and which affect the interests of professional engineers and scientists.

(*b*). The council may interest itself in matters of national importance to specific groups of engineers and scientists only on their direct request.

4. The method of procedure shall be:

(*a*). The council shall meet in Ottawa at the call of the chairman, but in any case at intervals of not more than three months.

(*b*). No action shall be taken by the council unless agreed upon by two-thirds of the members of the council.

5. In order to finance the activities of the council for the year 1945, the participating societies are asked to contribute ten cents (10¢) per member. (The same contribution was assessed in 1946).

6. Travelling and living expenses of representatives attending council meetings shall not be borne by the council.

The first chairman of the Canadian Council of Professional Engineers and Scientists was W. P. Dobson (F' 43) president of the Dominion Council of Professional Engineers and member of the Engineering Institute of Canada.

The societies supporting the Canadian Council of Professional Engineers and Scientists were, as of August 1946: Agricultural Institute of Canada; American

Institute of Electrical Engineers, Canada District 10; Canadian Association of Professional Physicists; Canadian Institute of Mining and Metallurgy; Canadian Institute of Surveying; Canadian Society of Forest Engineers; The Chemical Institute of Canada; Dominion Council of Federated Professional Employees; Dominion Council of Professional Engineers; Institute of Radio Engineers, Canadian Council; and the Royal Architectural Institute of Canada.

At this point it is of interest to note that the Dominion Council of Federated Professional Employees was formed to co-ordinate the activities of the Ontario and Quebec Federations of Professional Employees which stem from Order-In-Council *PC-1003* (Wartime Labour Relations Regulations). These federations are constituted to permit collective bargaining for professional employees in applied science and research by such employees. Briefly, they make provision for professional employees availing themselves of the facilities offered by present legislation, ethically and efficiently, without impairment of the true professional spirit. As Canadian legislation does not permit either voluntary organizations or the Provincial Associations of Professional Engineers to undertake collective bargaining for professional employees, the exclusive purpose of the federations is to advise and assist members in their employer–employee relations. The Ontario Federation covers professional engineers only but the Quebec Federation undertakes to cover all professional employees of applied science and research in Quebec, including forestry engineers, land surveyors, architects, and graduates in the field of chemical, metallurgical, physical, geological, and biological science. Membership is restricted to professional employees in applied science and research, and all candidates training for such fields. All applicants for membership, who are qualified to practice their profession, must be members, as required by law, of their appropriate licensing body.

## NEED FOR CO-ORDINATION

Growing out of the legislative division of powers between the dominion and the provinces, the voluntary societies must, in large part, confine themselves to the technical and social activities of engineers and scientists, aside from the broader aspects of professional interests. Licensing and policing powers are the field of the Provincial Professional Associations. Collective bargaining, by law, is restricted to employee engineers and scientists. This trinity of organizations for professional engineers and scientists emphasizes the need for a co-ordinating agency such as the Canadian Council of Professional Engineers and Scientists.

It may be said that for the first time in the history of Canada the common interests of those professionally trained in all branches of science and engineering can be co-ordinated and represented by one national group. The base is broad and will be broader still when the Engineering Institute of Canada accepts the standing invitation to take its seat at the council table.

The Canadian Council of Professional Engineers and Scientists interferes in no way with the autonomy of co-operating national organizations. It concerns itself only with matters that affect the whole field of science and engineers, and may deal with a matter of exclusive concern to a particular group only upon the request of those affected and only upon agreement of the council. Although the participating bodies have given authorization for immediate action to be taken in emergency without reference to them, it is a matter of observation that all representatives have on every occasion been particularly careful to associate themselves only with proposals which they are convinced will find favor with their organizations.

Much work has been accomplished by the council. The first annual report calls attention to representations to the prime minister of Canada regarding salary schedules and classifications of professional engineers and scientists in public service, and progress has been made in the establishment of close liaison with the Civil Service Commission of Canada. Strong representations have been made to the Canadian Government with respect to provision of a permanent national employment service for technical persons, so continuing the splendid war job of the Wartime Bureau of Technical Personnel.

The council has paid particular attention to collective bargaining for professional engineers and scientists, through the presentation of the views of the co-operating organizations to the minister of labor and to the National Labour Relations Board, and by assistance to collective bargaining groups in their relations with officers of the Canadian Government in regard to specific problems which have arisen from time to time. It has undertaken worthwhile studies with respect to national development in the fields of science, professional welfare, and research.

To sum up, an efficient organization co-ordinating the activities of the widely diversified voluntary and professional organizations of engineers and scientists in Canada is functioning. It is doing much useful work and it has a shining goal. Through the endeavor of leaders in the professional engineering and scientific societies of Canada it will and must obtain that unity necessary to the fullest attainment of public recognition, professional stature, and ability to render those public services for which professional engineers and scientists are qualified so well.

With the current record enrollment in engineering and related scientific studies in Canadian universities, largely by exservicemen, it is most essential that all engineers and scientists of good will and leadership aid in reaching that professional unity and stature which is the goal of the Canadian Council of Professional Engineers and Scientists.

# Induction and Dielectric Heating

KENNARD PINDER
MEMBER AIEE

**The success of dielectric and induction heating in wartime production indicates their continued successful use in peacetime industry for many applications which ordinary heating processes have not accomplished. Though the methods of heat generation are vastly different, both types of heating are based on disturbance of the molecular structure. Each, however, has its individual field of application, with induction heating intended primarily for metals, while dielectric heating is applied primarily to nonconductors.**

PROBABLY THE greatest contribution to the art of heating, heat treating, and brazing made during the past decade has been the progress of induction heating; certainly the heating of nonmetallic materials by high frequency has taken an increasingly important part during the last three years. The industrial use of a-c heating, either induction or dielectric, is miraculous on several counts and has enabled the inclusion in production of many operations that previously could not be accomplished at all, much less on a production basis. In anticipation of the ever-increasing demand for these heating twins, this discussion will attempt the following:

1. To outline the fundamental principles of induction and dielectric heating.
2. To point out various general types of operations where induction or dielectric heating can and is being used to save time, cost, equipment, and/or material.
3. To furnish some data on the type and sizes of units to apply.

Before describing either the processes or equipment the fundamental principles of both induction and dielectric heating should be reviewed briefly. The essential item to note is that *friction* causes *heat*. If a piece of iron is bent very rapidly, it becomes hot at the bend because the rapid movement upsets the molecular structure of the material. Both induction and dielectric heating are based upon molecular structure disturbances.

Induction heating is the generation of heat in conductive materials. The heating of ferrous metals is caused by placing the metal within a field set up by a coil that is formed of one or more primary turns of copper conductor. The heating in this case is produced by:

1. Eddy currents.
2. Hysteresis.
3. Resistance to the heavy secondary currents.

Despite the resistance of the metal, the hysteresis effect, oscillating in motion, forces changes in the molecular structure of the material at the rate of the applied frequency giving double the frequency number of "twists and turns" a second, thus generating friction, which, in turn, generates heat. This action continues until the metal reaches its critical temperature, after which further heating is induced by the eddy currents. The temperature obtained depends upon the strength of the magnetic field, the period of time the energizing current is maintained, and the analysis and mass of the metal being treated.

The heating of nonferrous metals is accomplished by the same means, but is due to that induced by eddy currents alone. These currents are circulating currents, generated within the metal itself, creating friction and thus heat. They are caused by the varying density of the magnetic field in which the metal has been placed.

Dielectric heating differs from induction heating in that it is essentially a voltage phenomenon and has the ability to create heat within nonmetallic and poor-conducting material. The two types of heat also differ on

**Table I. Uses of Equipment for Induction and Dielectric Heating**

| Frequency | Power Source | Power Range | Heating Application |
|---|---|---|---|
| 60 cycles | Network | Unlimited | Chemical vats, dies for thermoplastics, and so forth, annealing or heating charges to low temperatures |
| 180–540 cycles | Motor-generator | Unlimited | Preheating, annealing, or heating magnetic charges, heating dies, rolls, and so forth, drying |
| Up to 1,500 cycles | Mercury arc converters | 250 kw and up | Same fields as those noted above for 60 cycles and 180–540 cycles, and below for 1–12 kc |
| 1–12 kc | Motor-generator | To 1,250 kw and up | Main field—commercial induction heating, melting, and heat treating |
| 20–60 kc | Mercury-hydrogen spark-gap converter | To 40 kw | Laboratory and small-scale heating, melting, and heat-treating |
| 1–500 kc | Quenched spark-gap or vacuum tube converter | To 200 kw | Special surface-heating applications, heating small charge where coupling is poor, degassing vacuum tubes, therapeutics |
| 1–50 megacycles | Vacuum tube converter | To 200 kw depending on frequency | Dielectric heating, special surface-heating applications, degassing vacuum tubes, therapeutics |

Essential substance of a paper presented before a meeting of the Philadelphia Section, February 12, 1945.

**Kennard Pinder** is senior electrical engineer, engineering department, E. I. du Pont de Nemours and Company, Wilmington, Del.

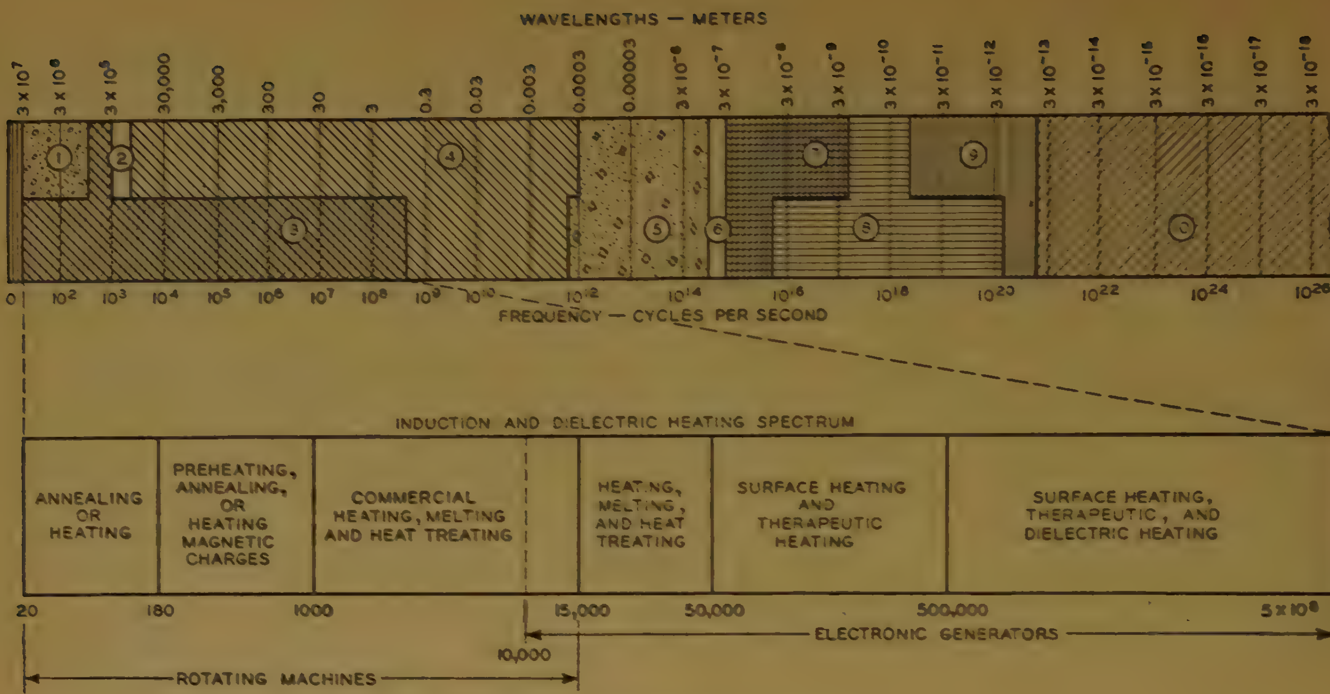
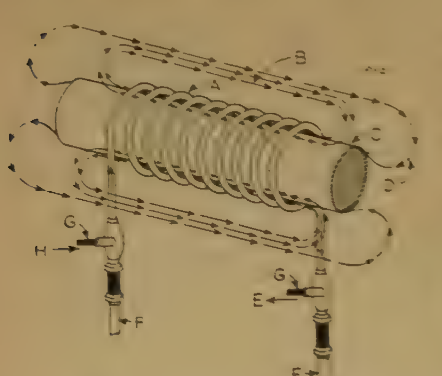



**Figure 1. Electromagnetic spectrum**

*1. Power and light* *2. Audio frequencies* *3. Induction and dielectric heating* *4. Radio* *5. Infrared radiation* *6. Visible light* *7. Ultraviolet radiation* *8. X rays* *9. Gamma rays* *10. Secondary cosmic rays*

the same general principle that makes a capacitor different from an induction coil.

Dielectric heating is based on the physical law that molecules in a material can be disturbed. Without power on the electrodes the electron orbits of the atoms comprising the dielectric material are unstrained. With a high voltage potential applied to the plates, the electron orbits are strained, first toward one electrode and then toward the other, depending upon the polarity on the electrodes. This disturbance causes friction between the various atoms and this friction creates heat. The difference between good conductors and poor conductors is represented by the degree of freedom of the so-called "orbit electrons." By applying very high frequencies to a material, the atoms are subjected to a terrific disturbance. Within limits, the higher the frequency the greater the heat production.



*A—Inductor coil*
*B—Magnetic flux in air*
*C—Metal to be heated*
*D—Flux in surface layer of work*
*E—Current out*
*F—Connections for cooling water*
*G—A-c leads*
*H—Current in*

**Figure 2. Inductor coil for induction heating**[4]

The methods of heat generation and its effect on the charge are widely different for the types being discussed, but either induction or dielectric heating is the raising of the temperature of any material by the electrical generation of heat within the material and not by any other means, such as convection, conduction, or radiation. As indicated in the foregoing, the use of induction heating usually is associated with the heating of metals, whereas dielectric heating primarily is intended for the heating of nonconductors. Thus, each method has its own distinctive field, but occasionally some substance might present a choice of either of these heating methods.

## ELECTROMAGNETIC SPECTRUM

Figure 1 shows the electromagnetic spectrum and the portions of the waves which manifest themselves in a variety of ways, depending upon their wave-length characteristics. The magnetic spectrum is very interesting, and as our knowledge of radiation phenomena has improved, uses have been found for practically all wave lengths. It is also interesting to note the extremely limited range associated with vision. If it were not for the radiation from approximately 4,000 to 7,700 angstroms (extreme violet to extreme red), visual sensation would be lacking. Power engineers usually think in terms of the standard 60-cycle frequency where a wave length is 3,100 miles. In dielectric heating, one must think of megacycles and hundreds of megacycles where wave lengths are a matter of feet and inches (about one meter for 300 megacycles). A considerable revision of thinking is necessary in evaluating circuit constants, the

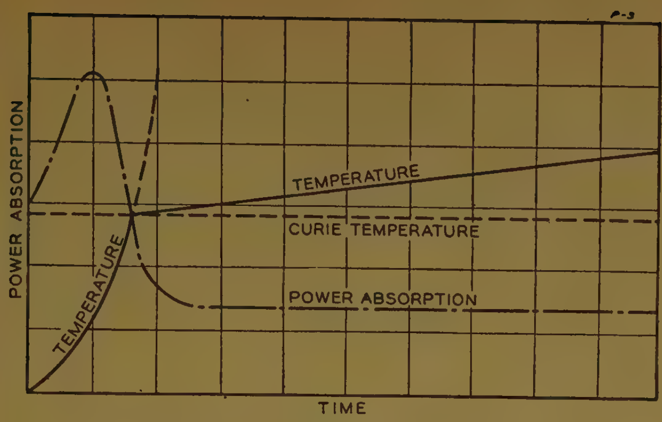



**Figure 3. Power absorption as a function of heating time[5]**

performance of dielectric (insulating) material, and even the characteristics of the current itself.

The induction and dielectric heating section of the spectrum shows the frequencies required for certain types of work to be done. Frequencies from 20 to 15,000 cycles per second normally are produced by rotating machines. This range covers a great portion of the commercial applications for heat treating, melting, and annealing.

Frequencies of 3,000 and 10,000 cycles per second obtained from rotating inductor-type alternators are relatively standard and are used for heating where rather large pieces are to be treated.

For heating material with rather thin sections, for hardening steel where a thin case depth is required, and for heating nonmagnetic materials, frequencies from 100 kc to 450 kc obtained from vacuum tube oscillators are best. The upper frequency limit in this frequency band usually is set at 450 kc in order to avoid any possibility of interference with the 500-kc frequency assigned to ships' distress calls and the broadcast band which extends from 550 kc to 1,500 kc.

For dielectric heating and special heat treating operations such as surface hardening, frequencies of the order of two megacycles to 50 megacycles obtained from vacuum tube oscillators usually are employed.

Table I supplements the dielectric heating section of the spectrum shown in Figure 1, and gives in detail the types of generating equipment that are obtainable commercially for the various frequency ranges.

## INDUCTOR COIL

Figure 2 shows the work piece in an inductor coil. When an alternating current flows in any conductor, an alternating magnetic field is set up in the surrounding area. Likewise, when any conducting material is placed in an alternating magnetic field, a current flow due to the change of magnetic flux caused by the induced electromotive force, is set up in that material. This current is such that the countermagnetic field generated by it will tend to cancel the existing field.

Inasmuch as the external magnetic flux must penetrate the surface before reaching the interior of the conducting material, the greater part of the current flow will be near the surface. The intensity of the counter-magnetic field which is set up by the current flow in the body is a function of the frequency. As the frequency is increased, the current flowing on or near the surface becomes more effective in generating the total counter-magnetic field and less current will flow in the layers below the surface. More than 90 per cent of the heat is released within a few thousandths of an inch of the surface of the metal. This skin effect is known as "depth of penetration."

The inductor coil can be thought of as the primary winding of a transformer with the charge being a single-turn secondary winding.

The following equation gives a measure of the depth of penetration of the heat for any given frequency and material:

$$d=\frac{\sqrt{\rho 10^9}}{2\pi\sqrt{2\mu f}}=3{,}560\sqrt{\frac{\rho}{\mu f}}=3{,}560/\sqrt{\lambda\mu f}$$

where

$d$ = depth of penetration in centimeters
$\rho$ = the resistivity of the material in ohms per cubic centimeter
$\mu$ = the permeability of the material = 1 for nonmagnetic charges
$f$ = frequency, cycles per second
$\lambda$ = conductivity of the material in mhos per cubic centimeter

This formula shows that as the frequency is increased, the penetration of the induced current is reduced, and the speed of heating is stepped up. With low frequencies, more of the mass of the metal will be heated, but the time required to heat to same temperature is longer for the same power input. When it is desirable to heat a solid cross section rather than cylindrical or surface heating, the following formula can be used to determine the most desirable frequency:

$$f=\frac{\rho\times 1.55\times 10^6}{\mu r^2}$$

where

$f$ = frequency, cycles per second
$\rho$ = resistivity in ohms per centimeter[3]
$\mu$ = permeability of the material being heated
$r$ = radius of work in centimeters

**Table II. Depth of Penetration of Induced Currents in Millimeters**

| | Frequency | | | | | | |
|---|---|---|---|---|---|---|---|
| Material | 100 Cycles | 1 Kc | 10 Kc | 100 Kc | 1 Mega-cycle | 10 Mega-cycles | 100 Mega-cycles |
| Steel (cold) | 320 | 120 | 32 | 12 | 3.2 | 1.2 | 0.32 |
| Steel (hot) | | 2,950 | 945 | 295 | 94.5 | 29.5 | 9.45 |
| Brass | | | 220 | 70 | 22.0 | 7.0 | 2.2 |
| Aluminum | | | 160 | 50 | 16.0 | 5.0 | 1.6 |
| Copper | | | 100 | 32 | 10.0 | 3.2 | 1.0 |

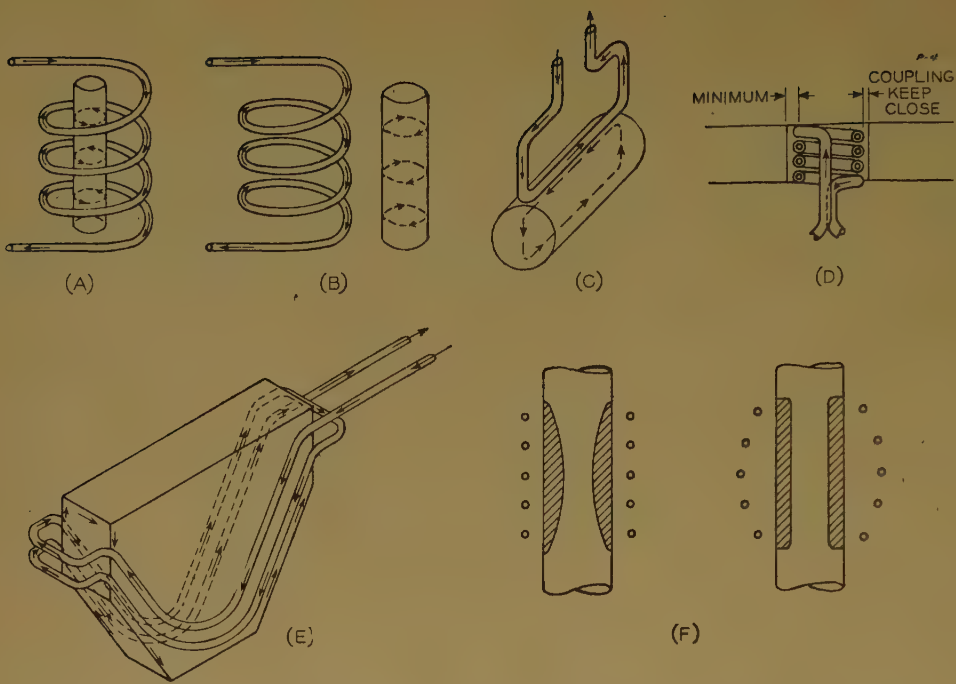



**Figure 4. Direction of current flow and control of uniformity in induction heating[6]**

For typical values for the depth of penetration for common materials at various frequencies see Table II.

## RATE OF HEAT DEVELOPMENT

As mentioned previously, the heat producing losses in magnetic materials are divided into two classes:

1. Hysteresis losses. These are directly proportional to the frequency of the magnetic field.

2. Eddy current losses. These are proportional to the square of the current flowing and also can be considered to be proportional to the square of the frequency and the field strength.

In general, the value of heat created by hysteresis loss is so small in comparison to the eddy current losses that it can be discounted, particularly if the temperature of the work piece exceeds 500 degrees centigrade.

The rigorous equations for eddy current losses are quite complex and have to be analyzed by means of partial differential equations whose solutions are based on Bessel functions of a-c machinery. However, the following approximate formula shows the relations of the the various factors for the power dissipated as heat:

$$P=\frac{H^2\sqrt{\rho\mu f}}{8\pi}=\frac{I^2N^2K\sqrt{\rho\mu f}}{8\pi}$$

where

$P$ = power dissipated as eddy currents
$H$ = tangential component of magnetic flux at surface of charge
$\rho$ = resistivity of charge
$\mu$ = permeability of charge
$f$ = frequency
$I$ = coil current
$N$ = number of effective turns in coil
$K$ = constant

This formula cannot be applied to practical problems with any degree of accuracy because such factors as the primary and secondary resistances, the primary and secondary reactances, and the combined circuit impedance have to be calculated to determine the power, power factor, and kilovolt-ampere requirements.

With reference to the speed of heating versus frequency, there is no definite relation between frequency and the speed of heating unless the element of power also is brought into the picture. With sufficient power, the speed of heating can be made the same over wide variations in frequency; however, when the available power is limited because of the facilities available, the rate of heating, or the power absorbed, will increase nearly in direct proportion to the square root of either the frequency or the permeability or the resistivity of the charge.

Regardless of the time interval or method, electrical or otherwise, the same amount of energy is required to heat a given piece through a specific temperature rise. Power input is dependent upon how quickly the heating is to be accomplished. It requires about 0.37 kilowatt-hour and 0.50 kilowatt-hour to melt one pound of copper and nickel, respectively.

## CURIE TEMPERATURES

In the high frequency induction heating of ferrous metals the heating cycle is divided into two distinct regions. The dividing point is approximately 775 degrees centigrade. This is known as the Curie tempera-

**Table III. Approximate Installed Cost of Induction and Dielectric Heating Equipment**

| Type of Equipment | Range in Frequency | Range in Power (Kw) | Cost Per Kilowatt (Dollars) |
|---|---|---|---|
| Motor-generator sets | Up to 9,600 cycles | 50–1,200 | 230–100 |
| Spark-gap converters | 15,000–100,000 cycles | 3–40 | 270–180 |
| Vacuum tube converters | 100–400 kc | 5–100 | 600–350 |
| Vacuum tube converters | 2–40 megacycles | 2–200 | 1,000–500 |

The price of electronic heating equipment varies considerably from one manufacturer to another and, in general, represents value received when the equipment is bought from a reputable manufacturer. Based upon a cost of one cent per kilowatt-hour for power from the mains, the cost of power and vacuum tube replacements to operate electronic induction heating equipment continuously at full power output is approximately three cents per kilowatt-hour of high frequency power. The unit costs vary somewhat from the figure given, depending on the size of the equipment.

ture. At this temperature the metal loses its magnetic properties and becomes nonmagnetic. The amount of power which is absorbed by the charge and converted into heat is determined by the density of the high frequency magnetic field. This, in turn, is a direct function of the magnetic permeability of the metal.

Figure 3 shows that at the beginning of the heating cycle the permeability increases with temperature but at the Curie temperature, the power absorption drops rapidly below the rate of the original rise due to the low magnetic field density resulting from the loss of permeability.[1]

From an electrical point of view the behavior of the material in the two regions corresponds to a condition where a generator had to supply power to a low impedance load in comparison to a high impedance load after the Curie point of magnetic transformation was reached.

## DIRECTION OF CURRENT FLOW IN INDUCTION HEATING

The induction coil can be designed to set up a magnetic field of a certain shape and cause currents to flow in desired areas in the charge. These currents flow in closed loops in the same plane as the coil current.

Figure 4*A* shows the current flow in a charge when it is within the coil. Figure 4*B* shows a similar bar placed close to the outside of the coil. The current still will flow in the bar as before, but at a much smaller magnitude as the magnetic flux density outside the coil is less than within it. Other parts of Figure 4 serve to illustrate the application of the current flow in both the coil and the part being heated. The heating is proportional to the amount of flux impinging on the surface of the charge while the amount of flux varies inversely as the square of the distance. Work coils have various shapes, as shown, to follow the contours of the work pieces being treated. In regard to clearance, about 3/32 inch to 1/8 inch will produce about as strong a magnetic field as practicable. By proper design of the coil, local heating of small sections of large parts can be accomplished readily.

There are also many applications where the metal can be heated by continuously passing the charge through a coil instead of letting it remain stationary in the coil during the heating cycle and then removing it. By this method it is possible to introduce cold metal into the coil at a constant rate and draw maximum power from the source. This is contrary to the usual falling off of load as the temperature of the metal rises which causes a loss of magnetic properties and the resultant diminishing of the flux density.

## DESIGN OF AN INDUCTOR COIL

The design of an inductor coil is governed by the nature of the work it is to do and the type of generator used. The four important factors which influence the strength of the magnetic field of an inductor coil are

1. The frequency.
2. The amount of current flowing in the coil.
3. The number of turns or loops in the coil.
4. The proximity of the coil to the charge.

The flux density is greatest at the conductors themselves, and diminishes rapidly in the surrounding space.

In induction heating applications, the coils are usually of the single layer type but can contain one or more coils for lower frequencies. Coil inductor may be of round, square, or irregular sections, flat or disk shaped, or shaped to fit the contour of the charge. For nonuniform heating, coils can be wound concentrated about any part where heating is desired. Interior heating also can be accomplished with internal coils similar to the one shown in Figure 4*D*. With this type of heating it is necessary to keep close coupling. It is not possible to heat the interior of a tube for any appreciable length, as there is a limit to the length of surface which can be heated at one

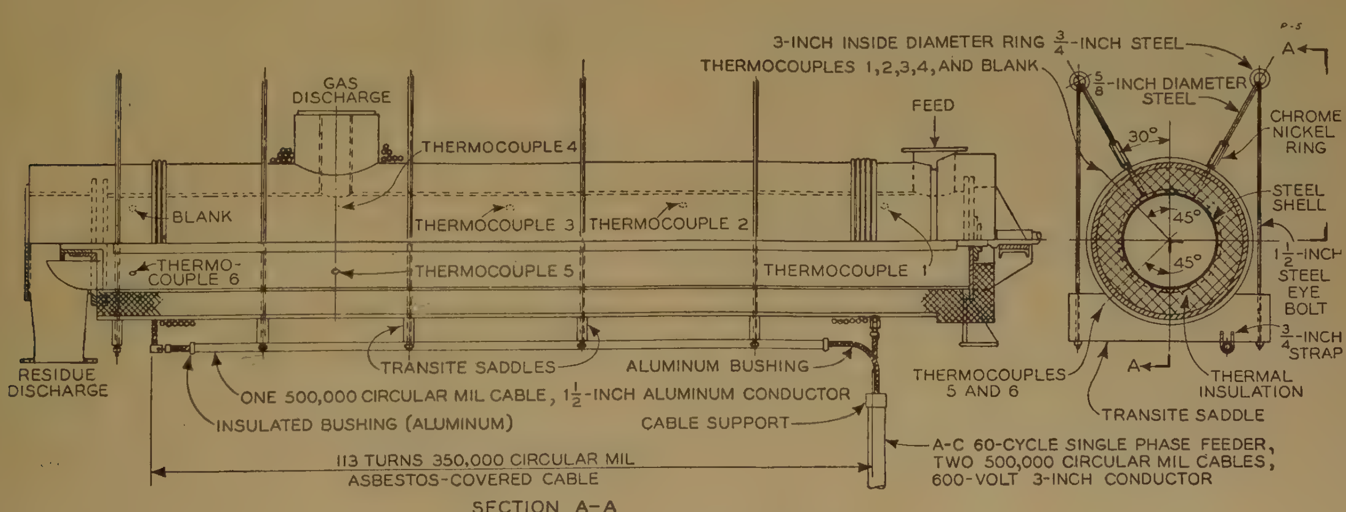



**Figure 5. Tube heated by 60-cycle induction**

*Section A-A—Typical section through tube*

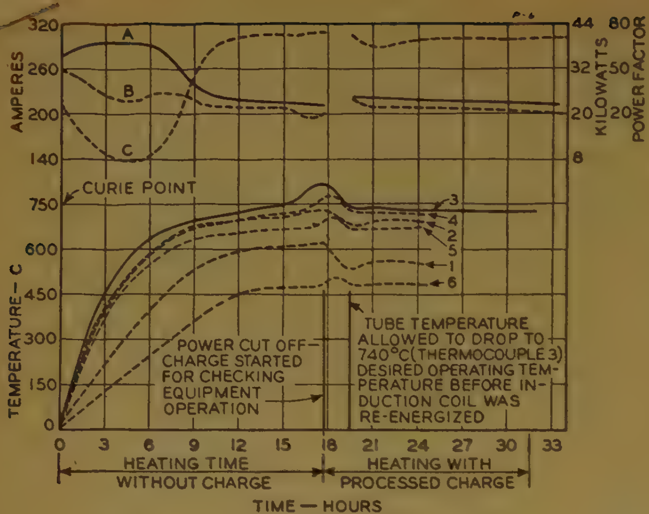



**Figure 6. Curves for induction heated tube**

*A—Power factor B—Kilowatts C—Amperes*

*Numbers 1 through 6 indicate thermocouples*

time, and also it is impractical to feed the coil through the part for any distance greater than about two feet.

Several interrelated variables, such as the shape of the inductor coil, the amount of power required to achieve desired results, frequencies of the current, and the time, are important factors that have to be considered in order to produce and control magnetic fields for induction heating applications.

Some of the important principles to be observed in the design of inductor coils are in the following:

1. Coil shape should be in proper relation to work surface because the heat pattern will resemble closely the shape of the coil, especially where close coupling is being used.

2. Coils can be of the single turn or multiturn type, fabricated, multiple, series-connected, or cast to shape. They must be made to suit the particular application, which often is accomplished by actual cut-and-try method.

3. Copper is the best material for coil construction. Coils usually are made of tubing 1/8 inch to 1/4 inch outside diameter. (Minimum diameter is limited by the amount of cooling water which is necessary to carry away the heat developed in the coil.) When heating the outside of the work, the outside diameter of the tubing used is not too important but when internal heating is desired, the inside diameter of the inductor should be relatively large as thin inductors are much more efficient for internal heating.

4. In multiturn coils, all parts of the loops usually have the same spacing to the work. This is particularly important for internal heating, inasmuch as the heat transfer is only about 50 to 60 per cent that of outside heating as less magnetic flux is concentrated on the work surface. Coupling is very important for internal heating and should be 1/16 inch, or less, if possible, in order that the over-all distance from the surface of the hole being heated to the inner surface of the coil is held to a minimum. A flattened tubing coil also will prove advantageous.

5. The leads from the coil to the generator carry current in the opposite direction, and the spacing between them should be close in order to avoid excessive inductance losses.

6. If it is desired to concentrate the available power as much as possible, a single-turn coil will be most effective. For an even distribution of heat, a helical coil should not be greater in length than four times its diameter. Multiturn coils exceeding the proportions given may be used successfully for heating rather thin sections and in annealing operations.

7. When dissimilar metals are being heated for brazing, it is necessary to concentrate the heat on the slowest heating metal. (Magnetic steel heats more easily than any other metal, followed, in order, by stainless steel, brass, copper, and silver.)

8. More uniform heating often is obtained by rotating the charge within, or, in the case of internal heating, without the coil.

9. Accurate control of the uniformity of heating of the hardened area is obtained only by the proper design of the coil. Figure 4*F* indicates how the heating depth varies for a straight-sided coil, and how the depth can be made more uniform with a barrel-shaped coil.

The inductor efficiency, or the ratio of heat generated in the charge to the power delivered, depends upon the material making up the charge, its physical dimensions, the radius of the inductor coil, and the frequency. For low frequencies, the inductor efficiency is low and increases as the frequency is increased up to some operating value, depending upon variables noted herein, above which value there will be no further gain in efficiency.

## LOW FREQUENCY HEATING

A-c heating frequently is thought of as being accomplished at "high frequency." This is not always so. Power system frequency of 60 cycles can be used for induction heating of localized areas of metals for forging and upsetting. When the metal is a good conductor and is quite thick, and it is to be heated throughout,

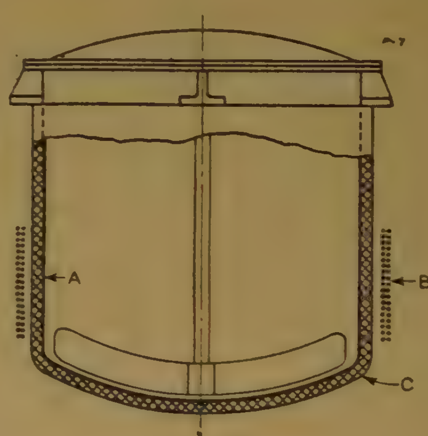



**Figure 7. Typical arrangement of an induction heated kettle**

*A—Steel shell*
*B—Induction coil; 38 turns, two layers*
*C—Thermal insulation*

power frequency system will be the most economical power supply.

These low frequencies also are used to heat chemical process equipment such as autoclaves, retorts, large chemical vats, pipe lines, and valves. The process is particularly useful where the absence of flames and fumes is an advantage. A large majority of the induction heating applications of process equipment in chemical plants has been of the low frequency type.

Figure 5 shows the layout of a horizontal metal tube designed to head a continuous feed of chemical sludge to 750 degrees centigrade. Thermal insulation was in-

Table IV. Factors in Selection of Electric Furnace Types

| | Arc Furnaces | Coil or Electrode Furnaces, Directly Heated | | | | Indirectly Heated |
|---|---|---|---|---|---|---|
| | | Induction | | Electrode | | |
| | | High Frequency | Low Frequency | High Frequency Capacitance | Low Frequency | |
| **Temperature Limit** | 3,500 degrees centigrade | Limited only by refractoriness of lining | | | | 1,500 degrees centigrade |
| Melting | x | x | x | | x | |
| Heat treating of metals | | x | x | | | x |
| Heat treating of nonconductors | | | | x | | x |
| **Advantages** | | | | | | |
| Melting | Heated slag gives freedom in selection of slag. Freedom in selection of furnace lining material | High melting speed, stirring action of slag and metal by electromagnetic forces | | Any nonmetallic material can be heated by high frequency currents | | |
| Heat treatment of metals | | Rapid heating of a thin layer | | | | High thermal efficiency. Furnaces independent of shape of piece |
| Heat treatment of nonconductors | | | | Heat generated within the body | | Independent of shape. Great flexibility |

stalled over the pipe and over the thermal insulation a split transite pipe which acted as a winding form for the induction coil.

Calculations of the heating requirements and the electrical factors showed that at 230 volts, 60 cycles, single phase, 115 turns of 350,000 circular mil cable with a power input to the coil of about 75 kva or 325 amperes at a power factor of 30 per cent would be necessary.

How closely these calculations were matched with the unit under operating conditions is shown in Figure 6, which gives the curves of temperature, amperes, kilowatts, and power factor requirements under test.

Figure 7 shows an induction heated kettle made of steel plate and wound with a 38-turn two layer coil. Operating at 440 volts, single phase, 60 cycles, it took a heating up input of 180 kva at 55 per cent power factor. The power input automatically drops to 125 kva as the operating temperature of 450 degrees centigrade is reached.

Many autoclaves and large steel shells may be heated inductively to moderate temperatures better and more economically with low frequency than with heat supplied externally with resistance windings.

The heating of nonmagnetic materials cannot be accomplished readily with low frequency because only a low field intensity can be obtained and the rate of cutting with the lines of force of the conducting material to be heated within the inductor coil is too slow to develop currents in the material of a magnitude which will heat it as fast as it will lose heat through the best heat insulation, if the temperature becomes at all elevated.

## ADVANTAGES OF INDUCTION HEATING

Induction heating has several advantages over conventional methods of heating by conduction or radiation and convection from a hot body, such as a flame or walls of a furnace. These advantages include:

1. Energy transfer in induction heating can be at a rate as high as 100 to 250 Btu per minute per square inch, as compared to about 3 Btu per minute per square inch from the walls of a furnace held at 2,000 degrees Fahrenheit to a body at room temperature.

2. Very little heat is stored in the source. Induction heating puts the heat directly into the material to be heated and, when retained with suitable heat insulation, there is practically no limit to the temperature obtainable. Heating of the work piece starts immediately when power of the proper frequency is fed to the heating coil, and ceases as soon as the power is cut off. By properly proportioning the heating coil, heat can be generated rather uniformly throughout the mass, or local heating can be concentrated in any part.

3. Rapid rate of heating makes it possible to harden a shallow layer which follows accurately the contours of the surface, interior as well as exterior.

4. By being able to localize the heat zone, many soldering, brazing, and welding operations can be accomplished more quickly and neatly than is possible by using more conventional methods.

5. The only way to get heat into metallic parts entirely surrounded by a dielectric, such as a glass envelope, is by induction heating.

Table V. Characteristics of Materials for Induction Heating Applications

| Material | Average Specific Heat | Heat of Fusion (Btu Per Pound) | Melting Point (Degrees Centigrade) | Weight (Pounds Per Cubic Foot) | Resistivity (Microhms-Cubic Centimeter at 20 Degrees Centigrade) | Temperature Coefficient of Resistivity |
|---|---|---|---|---|---|---|
| Aluminum | 0.23 | 138 | 658 | 160 | 2.69 | 0.004 |
| Brass | 0.10 | | 930— | 525 | 6.0 | 0.004 |
| Graphite | 0.31 | | | 130 | 800 | |
| Lead, solid | 0.03 | 10 | 320 | 710 | 22 | 0.004 |
| Solder (50 per cent lead, 50 per cent tin) | 0.04 | 17 | 223 | 580 | 16 | 0.004 |
| Steel | 0.12 | | 1,400— | 490 | 10 | 0.007 |
| Tin | 0.056 | 25 | 232 | 455 | 11.5 | 0.004 |
| Zinc | 0.095 | 51 | 420 | 445 | 5.75 | 0.004 |

**Table VI. Characteristics of Materials for Dielectric Heating Applications**

| Material | Average Specific Heat | Weight (Pounds Per Cubic Foot) | Dielectric Constant | Power Factor (Per Cent) | Loss Factor |
|---|---|---|---|---|---|
| Air | 0.24 | 0.08 | 1 | 0.0 | 0.0 |
| Glass | 0.20 | 165 | 6.5 | 0.9 to 1.0 | 0.06 |
| Gypsum board | 0.40 | 65–72 | 1.4 | 8.0 to 9.0 | 0.11 to 0.13 |
| Leather | 0.36 | 56 | 4 | 4.0 to 5.0 | 0.16 to 0.20 |
| Lucite | 0.35 | 75 | 2.7 to 2.8 | 1.0 to 3.0 | 0.03 to 0.09 |
| Plastics | | | | | |
| Phenol formaldehyde | 0.30 | 78 | 4.5 to 6 | 4.0 to 8.0 | 0.20 to 0.50 |
| Urea formaldehyde | 0.40 | 83 | 6 to 7.7 | 3.0 | 0.18 to 0.23 |
| Vinyl | 0.24 to 0.32 | 95 | 3 to 5 | 2.5 to 5.0 | 0.08 to 0.25 |
| Cellulose acetate | 0.34 | 95 | 3 to 6 | 1.0 to 7.0 | 0.03 to 0.42 |
| Cellulose nitrate | 0.40 | 105 | 8 to 10 | 4.0 to 7.0 | 0.04 to 0.7 |
| Porcelain | 0.26 | 150 | 7 | 0.7 to 1.0 | 0.05 to 0.07 |
| Wood (dry-soft) | 0.40 | 32 | 5 | 6.5 | 0.32 |
| Wood (dry-hard) | 0.42 | 50 | 3 | 3.0 | 0.09 |

6. The induction heating process can be used to melt, dry, and cure coatings on metals.

7. Working conditions near induction heaters are better than those near gas or oil fired furnaces because almost all the heat is generated directly in the charge itself.

8. The charge will not be contaminated by fuel gases as is the case with other types of heating.

## INDUCTION HEATING FACTS

There are a number of important facts associated with induction heating which a person who is interested in the process should be acquainted with. For example, the depth of heating or penetration varies inversely as the square root of the frequency; the rate of heating is directly proportional to the square root of either the frequency and the permeability or resistivity of the charge; and with a given inductor coil and charge, much higher currents are necessary at the lower frequencies to produce a desired heating effect.

In addition, the power requirements vary and become lower as the temperature of the charge increases. Up to the Curie temperature of the material doubling the temperature reduces the kilovolt-ampere requirements about ten per cent.

There is no definite relation between frequency and speed of heating unless the element of power and the size of the charge also are considered. If the charge is large enough, the efficiency does not increase with increase of frequency.

The heat generation is greatest at the midsection of a single or two layer coil because of the interlinkages of flux from the coil turns. If at all possible the induction coil should be a single layer solenoid because it gives the maximum efficiency.

Lastly, by decreasing the number of turns, both heating effect and current requirements are increased.

## CAPACITOR ELECTRODES

In dielectric heating, the material is placed between two conducting plates as shown in Figure 8, and a high frequency alternating voltage is applied to the plates. Heat is caused by the power loss across the material. The cause of this loss is due both to the dielectric hysteresis, which corresponds somewhat to the hysteresis found in magnetic materials, and the actual current flow through the material because of the potential gradient existing across it. These losses are shown in Figure 10.

Just as in an electric motor, the ratio of the total loss

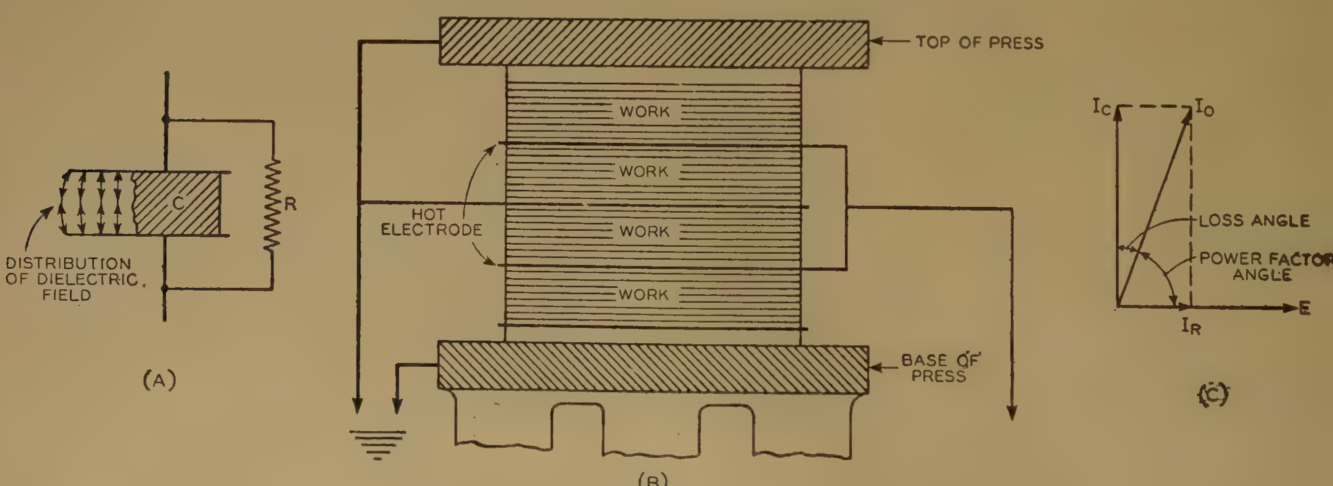



**Figure 8. Capacitor electrodes for dielectric heating**

*A—Equivalent circuit* *B—Schematic arrangement of work* *C—Vector diagram*

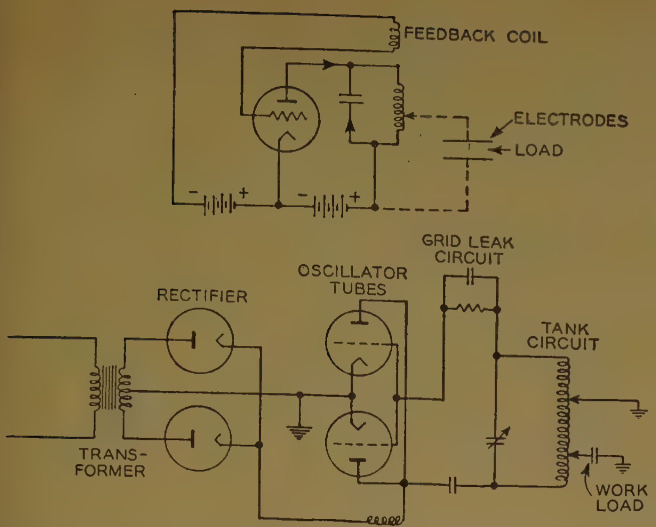



**Figure 9. Simple oscillator circuit (top) and basic diagram of a single phase electric-field heating circuit (bottom)**

to the total impressed volt-amperes is known as the power factor of the material. In many materials the power factor may vary with frequency and the losses are not necessarily directly proportional to the frequency at any fixed voltage.

## OSCILLATOR CIRCUITS AND GENERATORS

Figure 9 shows the flow of power in a dielectric heating circuit. The fundamental principles are quite simple. First, low voltage from a commercial a-c line is stepped up to a higher voltage and rectified. Second, normal frequency current is changed to radio frequency, which flows in the circuit by means of the well-known electromagnetic principle that a charged capacitor discharges into an inductance which, when the capacitor has become charged, will react to charge it to a reverse polarity. This process continues until the initial energy of the tank circuit has been converted into heat. For resonance the capacitive reactance equals the inductive reactance.

Rectified direct current is fed to oscillator tubes which supply high frequency alternating current to work through a tank circuit. The tank circuit comprises an inductance in shunt with a capacitance, one of which usually is variable. The combination is tuned to the stage output frequency. The work is held in a press and forms in effect the dielectric between the plates of a capacitor.

The vacuum tube is the best known means of obtaining negative resistance. This property of the vacuum tube in a properly designed circuit is all-important, for it is one of the major sources of sine waves at frequencies higher than are obtainable from rotating machinery.

## DIELECTRIC HEATING FACTS

In dielectric heating, heating of nonmetallic materials can be accomplished by a high frequency electric field. Heat by this means is produced directly in the material being treated. Energy is not transferred to the material as heat, but in the form of a rapidly alternating electric field. Thus, the normal barriers to heat flow do not enter the problem.

The rate of heat production can be as high as desired. The introduction of the factor of time in which the heating is accomplished merely fixes the necessary rate of energy output required for the process.

Dielectric heating produces a uniform temperature at all points within the heating field. Local overheating and undesirable side reactions occasioned thereby are avoided. Heating accomplished by this means is capable of critical control and can be stopped merely by cutting off the power.

The power expended in heating the material can be calculated by considering the material as a dielectric of a capacitor. It depends upon the impressed voltage, the frequency, the capacity, and the power factor of the material, or

$$W=\frac{E^2 2\pi fC \times \text{power factor} \times \text{efficiency}}{10^6}$$

where

$W$ = the energy dissipated in watts as heat in the dielectric
$E$ = voltage across the electrodes
$f$ = the frequency of alteration
$C$ = the capacity of the capacitor formed by the material being heated
power factor = the power factor of the material
efficiency = average over-all efficiency of power usage

The power required for heating can be calculated by the following formula:

$$H=\frac{MST \times 10^3}{56.9}$$

where

$H$ = energy required, watt minutes
$M$ = weight of material to be heated, pounds
$S$ = specific heat
$T$ = temperature rise, degrees Fahrenheit

For estimating purposes the capacity of a dielectric between two parallel plates can be calculated by the following formula:

$$C=\frac{2{,}248\,AK}{10^{10}d}$$

where

$C$ = capacity, microfarad
$A$ = area of one electrode, square inches
$d$ = distance between electrodes, inches
$K$ = dielectric constant

The foregoing equations indicate the problem of heating a dielectric material by high frequency to be relatively simple. The power requirements are set by the heat requirements of the piece to be heated and the time allowable. The minimum frequency can be calcu-

lated on the basis of the assumption that the power factor of the material remains constant with frequency. By converting the heat requirements per unit time into kilowatts and then dividing by the power factor of the material, the volt amperes required to be produced in the work are obtained. How the volts and amperes are proportioned then becomes a matter of choice with the maximum value of voltage determined by breakdown considerations.

By selecting the value for breakdown voltage and allowing a factor of safety for voltage determined by conditions, a maximum value of capacitive reactance that the load circuit may have is obtained. For a load circuit of this value, or lower, the minimum frequency may be established by a calculation of the capacitance and reactance of the load circuit.

## LOSS FACTOR

It was stated previously that the losses are not necessarily directly proportional to the frequency at any fixed voltage. Figure 10 shows the loss factor for different materials with reference to frequency.[2,8] The loss factor cannot be measured with mathematical accuracy because it is subject to considerable variation inasmuch as temperature, moisture content, and commercial composition are variable.

However, once the loss factors have been determined and the dielectric material to be heated can be clamped between the electrodes, the work involved in calculating dielectric heating problems can be made simple. The power absorbed by the dielectric is

$$P=1.4\times10^{-12}\times feV^2$$

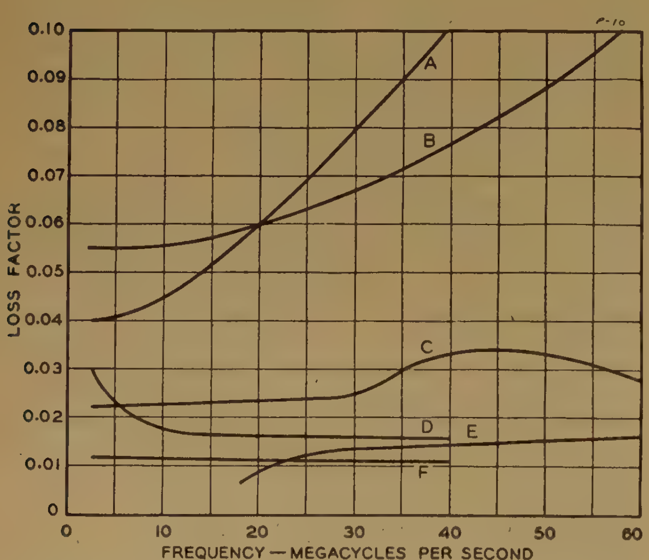



**Figure 10. Loss factor for different materials varying as a function of frequency[7]**

*A—Porcelain*
*B—Black plastic*
*C—Bakelite*
*D—Hard rubber*
*E—Hemp*
*F—Paper board (hard)*

where

$P$ = rate of heat energy generation in watts per cubic inch
$f$ = frequency in cycles per second
$e$ = loss factor of the material at frequency $f$ (power factor × dielectric constant of the material)
$V$ = root-mean-square voltage gradient in volts per inch

The loss factor for many materials classed as dielectrics has been established and usually falls between 0.02 and 0.07. Sometimes, however, it may be considerably higher. The usual root-mean-square voltage between plates for short spacing is 2 to 3 kv, but can be as high as 15 kv for treating relatively large thicknesses.

## ADVANTAGES AND DISADVANTAGES OF DIELECTRIC HEATING

Some of the advantages of dielectric heating are the following:

1. All parts of the material are heated uniformly by heat produced by dielectric losses within the product itself, regardless of poor thermal conductivity or thickness.

2. Temperature rise is rapid and its rate can be controlled.

3. There is no overshooting of heating upon stopping as a result of storage of heat in surrounding parts.

4. Process usually is not limited by high moisture content.

5. Process can be applied without damage to the surface or change in the internal structure. Surface checks and case hardening can be prevented. There is no capillary migration of liquid to the surface.

6. Time lost waiting for equipment to cool is eliminated when servicing or making change-over adjustments.

The disadvantages of dielectric heating include:

1. Over-all efficiency from electric power to heat is approximately 50 per cent as compared with theoretically 100 per cent of available heat for electric resistance heaters or the 70 or 80 per cent generally obtainable with fuel heating methods.

2. The initial cost of installation is high, varying from approximately $1,000 per kilowatt capacity for small units to $500 per kilowatt for large units.

3. The geometry of the material to be processed must be such that it is possible to introduce electrodes that are substantially equidistant at all points in a plane or with curvatures of large radii so that a more or less uniform field can be achieved and local hot spots prevented.

## APPLICATIONS OF DIELECTRIC HEATING

The principle of dielectric heating has been applied successfully to a number of processes. These include the setting and curing of plastics, as well as the preheating of both regular and irregular plastic sections prior to molding operations; the destruction of fungi and other infection in grain and cereals; the bonding of plywood and supercompressed compregnated wood; the manufacture of resin-bonding slabs of granulated cork; the softening of natural and synthetic rubber for masticating purposes, as well as the vulcanizing of rubber insulating compounds on wire and cable; and the drying of such materials as textiles, paper, and ceramics.

The dielectric heating process may be used in the cooking, sterilization, pasteurization, and enzyme control of food and drugs, and in the dehydration of food. In the latter case the food can have its moisture content reduced to one per cent in a partial vacuum. Dehydration to five per cent of the original moisture content reduces the weight of the food to about one tenth that of fresh food.

Dielectric heating also is adaptable to the fabrication of practically all nonconducting materials that are formed or processed by heat and may be used under adverse circumstances of heat conductivity and where uniform and rapid temperature rise is desirable. However, it appears that the most economical use of radio frequency power for drying purposes is to combine the operation with present drying methods; that is, remove as much of the water content as practicable by the usual drying method and then quickly finish the drying operation by dielectric heating.

No doubt many other applications, in addition to those listed, will become practical industrial processes as this new heating method becomes more familiar.

## CALCULATION OF DIELECTRIC HEATING REQUIREMENTS

The following items must be known in order to calculate dielectric heating requirements:

1. Material to be processed.
2. Weight per cubic foot and specific heat.
3. Electrical characteristics of material—dielectric constant, power factor (may be tested from sample).
4. Production in cubic feet or cubic inches per batch.
5. Maximum allowable heating time per batch.
6. Initial moisture content, in per cent of dry weight.
7. Final moisture content desired or allowable.
8. Maximum temperature desired or permissible.
9. Name and type of glue or resin in operation involving gluing or bonding.
10. Description of any desired change in bonding material.
11. Dimensions and shape of material to be processed.
12. Maximum production required per hour.
13. Characteristics of electric power available including quantity and approximate costs.

Two disturbing factors enter into many dielectric heating applications; namely, water and air.

Water makes the required power higher than that calculated from the specific heat of the material, even when present in small percentages. A moisture content of ten per cent often will double power required.

The heat energy required to convert water to steam is approximately 970 Btu per pound. Expressed in terms of kilowatt-hours, it is approximately 0.3 kilowatt-hour per pound of water vaporized. In drying problems, this factor plus that required to raise the water to final

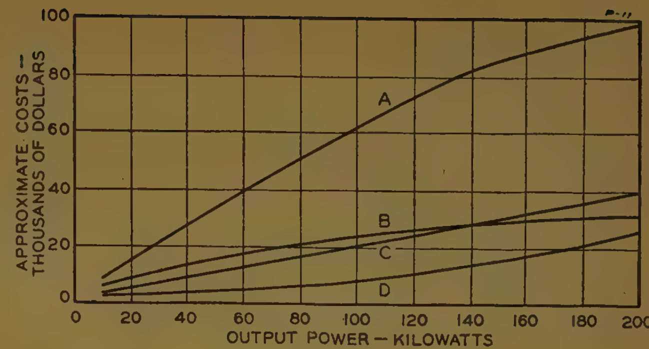



**Figure 11. Cost of radio frequency equipment and operating costs**

*A—Over-all installed costs* *C—Power costs*
*B—Depreciation per year* *D—Tube costs*

temperature of the dielectric must be added to the energy required to raise the material through the desired temperature range.

Air enters into the dielectric heating problem because of its effect on maximum operating voltage. It is usually necessary that the electrodes extend to or beyond the edge of the material being treated, thus the breakdown between the capacitor plates is determined by the dielectric strength of air. When the electrodes cannot be in contact with the work, the net result is a capacitor in which the dielectric is composed of two materials—the material being heated and air. Inasmuch as the power factor of air is essentially zero, the power involved for air is practically zero, but the voltages employed must be higher to provide the same potential gradient across the charge as would exist with contact electrodes. The potential distribution is expressed conveniently by the equation:

$$E_1 = \frac{E}{1+\dfrac{(K^{1}X_2)}{(K^{11}X_1)}}$$

where

$E_1$ = voltage across material
$E$ = total voltage between electrodes
$K^1$ = dielectric constant of material
$K^{11}$ = dielectric constant of air = 1
$X_1$ = thickness of material
$X_2$ = thickness of air

## ECONOMICS OF INDUCTION AND DIELECTRIC HEATING

The spectacular, except in showmanship, has little economic value and seldom transcends costs in importance. In most cases the problem of whether or not to purchase induction or dielectric heating equipment resolves itself into satisfactorily answering one of the following questions:

1. With this piece of equipment, can some operation be performed that cannot be done with existing equipment?

2. With this piece of equipment, how much savings can be made over a period of years?

Each kilowatt-hour generated by induction heating equipment costs more than equivalent heating by any of the more conventional means. The efficiency of the heating coil varies greatly with the shape and material of the work piece. In general, for heating magnetic steel, the efficiency of the heating coil may be approximately 80 per cent or better. For heating nonmagnetic materials the efficiency of the heating coil often will be in the range of 50 per cent to 70 per cent. In heating materials of very low resistivity or when mechanical limitations prevent the heating coil from closely surrounding the work, the efficiency of the coil may be less than 50 per cent. The over-all radio frequency efficiency of dielectric heating from commercial frequency to the work for the larger size units is approximately 50 to 60 per cent.

The installed costs of induction and dielectric heating equipment vary widely depending upon the application, type of generating equipment, and the control desired.

Figure 11 and Table III show the approximate operating and installed costs for high frequency heating equipment.

## CONCLUSIONS

Induction and dielectric heating are here to stay, and, as rapidly as peacetime efforts are replacing wartime efforts, the heating equipment installed for making guns, bombs, tanks, aircraft parts, and so forth, is being turned to peacetime trades. In order to avoid undesirable applications, it should be remembered that these heating twins, the induction coil and the capacitor plate, are not a "cure-all" for heating applications. Each application must be studied thoroughly and completely if its uses are to be applied successfully in industry.

Table IV gives the factors to be considered in selection of types of electric furnaces for various applications, and Tables V and VI list the principal characteristics of materials which usually are heated by induction or dielectric methods.

It is hoped that this analysis of the role of industrial heating will enable the user to apply induction and dielectric methods to work which these methods can do well.

**A specialist, one of the German scientists whose presence in the United States in connection with rocket and aviation research was revealed recently by the United States Army Ordnance Department and the Army Air Forces, assists in preparing a *V-2* rocket for firing at the Army Ordnance Proving Ground, White Sands, N. Mex. Preparation for launching of the missile is expedited by the new gantry crane. Assembly and firing of the rockets were supervised by the General Electric Company**

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# Comparisons of Railway Motive Power in the Pacific Northwest

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ASSOCIATE AIEE

**Reciprocating steam, Diesel-electric, and electric locomotives compete today for main-line freight and passenger assignments. It is doubtful if the present struggle for dominance among the three will be influenced greatly by other types of locomotives. Reciprocating steam locomotives have occupied a position of leadership since the coming of the railroad, but it is apparent that they face strong competition from Diesel-electric and electric motive power.**

THERE have been times when competition for steam locomotives appeared about to materialize, but each time something intervened to remove the immediate threat to their leadership. Between 30 and 40 years ago it was predicted freely that electrification was coming into recognition. Several things happened. World War I was fought and labor and materials that might have been invested in a great network of electrified railroads was used for other things. The natural advocates of electrification failed to agree among themselves on the question of what kind of a system of electrification should be encouraged. Fundamental objectives were lost sight of in the more heated than enlightened debates over the merits of alternating versus direct current. Enough uncertainty was cultivated in the minds of already steam-minded railroad officials to cause indefinite postponement of most electrification plans.

It was only a little more than ten years ago that Diesel-electric passenger locomotives first appeared in main-line service. They came with the early streamliners and to many casual travelers the words streamliner and Diesel are synonymous. It was likewise only about five years ago that the first of the so-called 5,400-horsepower 4-cab Diesel-electric main-line freight locomotives was delivered. Although the Diesel remained a poor competitor until 1940, it took but two years for it to overtake and then exceed the cumulative lead of new units placed in service that the steam locomotive had established over the preceding decade. Not until 1942 were road service freight units generally available. Main-line types are still relative newcomers to motive-power rosters, and the major statistical gains have been achieved by switching units.

Technical and economic factors that have enabled Diesel switching units to cause obsolescence among parallel steam types are operative in the field of main-line motive power and therefore warrant brief recital.

1. Diesel-electric units are able to motorize all their weight and hence produce relatively much greater tractive effort or hauling ability than otherwise comparable steam units.

2. With no fires to clean, ashes to dump, boilers to wash, and with less lost time for assorted other reasons, Diesels have demonstrated a higher degree of availability and reliability.

3. Diesel-electric switching units have demonstrated that they can replace steam switchers and almost invariably do a better job cheaper.

It has been established that Diesel units can cut repair costs in half and reduce fuel expense by two-thirds when they replace steam. Since in yard service less total investment frequently is required for a pool of Diesel switching locomotives it can be seen that there are many situations where continued steam operations are plainly uneconomic.

## ELECTRIFICATION AFFECTED BY TREND TOWARD DIESEL UNITS

Paradoxically the trend toward Diesel-electric switching units has advanced the cause of main-line electrification. Prior to the advent of the Diesels, it was necessary to erect a great deal of trolley before a railroad could achieve full benefits from electrification. The capital cost of providing relatively little-used trolley facilities was excessive, but if main-line movements only were to be

**Table I. Evaluation of Physical Characteristics and Hauling Abilities of Steam, Diesel, and Electric Motive Power Units Selected for Comparison**

| | Steam | Diesel | Electric |
|---|---|---|---|
| Total weight of locomotive fully loaded, tons | 532 | 477 | 517 |
| Total length of locomotive and tender, feet | 119 | 193 | 148 |
| Rail horsepower continuously available at 17.0 miles per hour | 4,098 | 5,582 | 6,800 |
| Maximum gross tons trailing on 1.0 per cent grade | 3,140 | 4,510 | 5,550 |
| Maximum gross tons trailing on 2.0 per cent grade | 1,500 | 2,280 | 2,850 |

Essential substance of technical paper 46-186, "Comparisons of Railway Motive Power for Operation in the Pacific Northwest," presented at the AIEE Pacific Coast meeting, Seattle, Wash., August 27–30, 1946, and published in AIEE TRANSACTIONS, volume 65, 1946, pages 1054–65.

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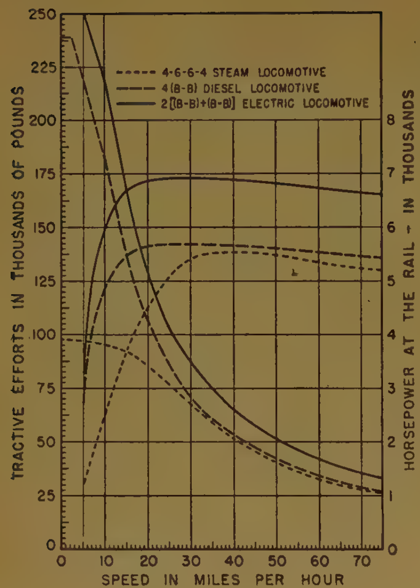


**Figure 1. Tractive effort and horsepower at the rail versus speed; steam, Diesel, and electric locomotives chosen for comparison**

handled electrically, leaving yard movements to be made with steam, the opportunities for smoke abatement would be reduced seriously. A Diesel-electric locomotive is related more closely to an electric locomotive than either of them is to a steam locomotive, and joint use of many kinds of facilities and maintenance staffs is entirely practicable. A combination of electrification and dieselization offers the next best thing to complete electrification in the reduction of smoke and fumes.

## FUNDAMENTAL DIFFERENCES IN MOTIVE POWER

Physical comparisons are complicated and produce differences of opinion which are not lessened when the subject is extended to include economic phases of motive power utilization. The electric locomotive causes most of the difficulties when comparisons are attempted. This is because both steam and Diesel locomotives are so-called independent units, requiring only coal or oil to burn and track to run on to ready them for service. The electric locomotive is a dependent unit and in addition to track requires suitable central station, transmission, and trolley facilities to generate and bring electric energy to its pantographs. Except for the location of the primary source of energy, modern Diesel road locomotives and modern electric locomotives are quite similar. Both of them are in reality electric locomotives. In fact, motor-generator type electric locomotives closely resemble late model Diesel-electric road units in many important respects. One leading manufacturer is using the same type of d-c traction motors on both locomotives. The d-c generators of the two locomotives also are not too different. However generators on Diesel locomotives are connected directly to the Diesel engines, whereas on motor-generator locomotives they are connected directly to synchronous motors which receive their energy from a relatively high voltage a-c trolley.

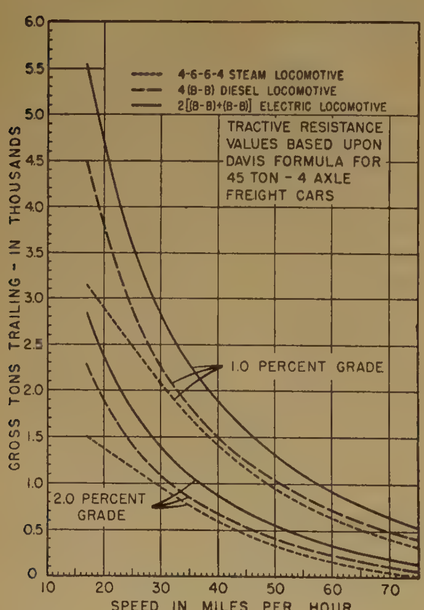


**Figure 2. Gross tons trailing versus speed for 1.0- and 2.0 - per - cent grades; steam, Diesel, and electric locomotives chosen for comparison**

## BASIC FACTORS GOVERNING COMPARISONS

Railroads in the Pacific Northwest are comparatively long thin lines of relatively low traffic density; much of the mileage is single-tracked; heavy grades are commonplace; and there is a substantial amount of horizontal curvature. Extremely high speeds are neither necessary nor desirable because the roads in this region are predominantly freight carriers. Therefore a kind of motive power was chosen that would deliver high tractive efforts at reasonable speeds rather than offer large horsepower output at high speeds. A single locomotive of each class was chosen.

## MOTIVE POWER CHOSEN FOR COMPARISON

Characteristic curves and basic performance data used in these comparisons were assembled from a number of sources and are believed to be factual and fair.

*Steam Locomotive.* Known in motive power circles by its wheel arrangement as a 4-6-6-4, it is of the single expansion articulated type. It is a 4-cylinder engine, in reality two separate engines served by one boiler and under the control of one engine crew. It bears the closest resemblance to multiple unit control available where electric motors are not used for traction purposes. With a driving wheel diameter of 69 inches a reasonable compromise is had between the objectives of high tractive effort demanded in freight service and high maximum speeds requisite to passenger operations. The top speed of the engine should be about 75.0 miles per hour and it appears to be about as satisfactory a universal passenger-freight type as is available for use in this part of the country.

*Diesel Locomotive.* The locomotive selected is of the 4-cab type with each cab having a B-B wheel arrangement (two 4-wheel swivel trucks). The gearing was selected with the purpose of limiting its top speed to

approximately match the top speed of the steam locomotive chosen or 75.0 miles per hour. Because at low speeds traction current is excessive, permissible temperature-rise fixes the minimum speed under continuous output conditions at about 17.0 miles per hour. Oil fired steam generators have been included for passenger train heating.

*Electric Locomotive.* It is obvious that the selection of the electric locomotive also implies selection of the type of system to be employed. However it is entirely beyond the scope of this article to delve into the ramifications of a choice of system. The primary criterion was the ability to deliver at least 15,000 kw to a point on the trolley system. To keep power supply facilities, including both the elements which normally are railroad-owned and those normally owned by the power supplier, at a minimum it seems essential to keep the trolley potential up to at least 12 kv. From the immediate practical standpoint this definitely suggests the necessity of choosing a 12-kv 25-cycle trolley system.

The choice of a frequency of 25 cycles requires explanation. Although a frequency lower than 25 cycles would be optimum, a frequency lower than 60 cycles is necessary because of at least two things.

1. The excessive reactance of 60 cycles.

2. The single phase unbalance that would be sustained by a power supplier attempting to feed 60 cycles to a railroad for direct application to the trolley. Changing frequency permits the assembly of what otherwise would be single-phase low-power-factor loads into a 3-phase unity-power-factor load.

Locomotives using d-c series motors for traction with d-c generators directly connected to synchronous motors supplied from the a-c trolley were chosen because of their load characteristic which makes full horsepower available in the low-speed range where it can be used effectively. The important points to note about the motor-generator type electric locomotive selected are:

1. The complete motorization of all weight.

2. The gearing of 3.75/1.00 which on 42-inch wheels gives about the same maximum and continuous speeds as the Diesel, that is, 75.0 and 17.0 miles per hour, respectively.

3. The provision of oil-fired train-heating equipment.

## HORSEPOWER AND TRACTIVE EFFORT COMPARISONS

Figure 1 shows characteristic rail horsepower and tractive effort curves. Attention is called to the point at which substantially full horsepower becomes available in the different locomotives. It will be noted that in the case of both the Diesel and the electric locomotives this occurs at about 17 miles per hour but is not reached until 30 miles per hour in the case of the steam. Even if there were some assured means of shifting the characteristic so that full horsepower were to be available earlier, it probably would be found that the adhesion would not be sufficient to permit full utilization of the additional tractive effort.

**Table II. Fuel and Energy Requirements and Equivalents**

| | Freight | Passenger | Total |
|---|---|---|---|
| Steam operations | | | |
| Pounds of coal per train | 109,440 | 78,900 | |
| Number of trains per day | 11.4 | 6.0 | 17.4 |
| Pounds of coal per day | 1,247,616 | 473,400 | 1,721,016 |
| Tons of coal per year | 227,690 | 86,395 | 314,085 |
| Diesel operations | | | |
| Gallons Diesel oil per train | 2,476.8 | 1,542.0 | |
| Number of trains per day | 7.5 | 6.0 | 13.5 |
| Gallons of Diesel oil per day | 18,576.0 | 9,252.0 | 27,828.0 |
| Gallons of Diesel oil per year | 6,780,240 | 3,376,980 | 10,157,220 |
| Electric operations* | | | |
| Purchased kilowatt-hours per train | 51,970 | 20,720 | |
| Number of trains per day | 6.0 | 6.0 | 12.0 |
| Purchased kilowatt-hours per day | 311,820 | 124,320 | 436,140 |
| Purchased kilowatt-hours per year | 113,814,300 | 45,376,800 | 159,191,100 |
| Fuel and energy equivalents | | | |
| Pounds of coal per kilowatt-hour | 4.00 | 3.81 | 3.95 |
| Pounds of coal per gallon of Diesel oil | 67.16 | 51.17 | 61.84 |
| Kilowatt-hours per gallon of Diesel oil | 16.79 | 13.44 | 15.67 |

* All electric energy is measured at the low side of the 3-phase 60-cycle transformers supplying the frequency changer stations.

## HAULING EFFICIENCY OF LOCOMOTIVES

Probably the most important single criterion for judging these locomotives is their ratings in terms of the trailing loads each of them could handle on various ruling grades. The comparisons for 1.0- and 2.0-per-cent grades are shown in Figure 2. From comparisons shown in Table I it was found that the electric locomotive excells in weight efficiency, length efficiency, and hauling

**Table III. Summaries of Train Crew and Locomotive Maintenance Expenses**

| | Steam | Diesel | Electric |
|---|---|---|---|
| Traffic statistics | | | |
| Number of freight trains per day | 11.4 | 7.5 | 6.0 |
| Freight train miles per day | 45,600 | 30,000 | 24,000 |
| Freight train miles per year | 1,664,000 | 1,095,000 | 876,000 |
| Number of passenger trains per day | 6.0 | 6.0 | 6.0 |
| Passenger train miles per day | 24,000 | 24,000 | 24,000 |
| Passenger train miles per year | 876,000 | 876,000 | 876,000 |
| Total locomotive miles per year (Line 3 plus line 6) | 2,540,400 | 1,971,000 | 1,752,000 |
| Train crew costs per year* | | | |
| Freight train miles at $.80 per mile | $1,313,200 | $ 876,000 | $ 700,800 |
| Passenger train miles at $.33 per mile | $ 289,080 | $ 289,080 | $ 289,080 |
| Total train crew costs | $1,620,280 | $1,165,080 | $ 989,880 |
| Locomotive maintenance costs per year** | | | |
| Steam locomotive repairs at $.55 per locomotive mile | $1,397,220 | | |
| Diesel locomotive repairs at $.55 per locomotive mile | | $1,084,050 | |
| Electric locomotive repairs at $.32 per locomotive mile | | | $ 560,640 |

* Assumed on basis of comparable wage rates prevailing in the Pacific-Northwest. Freight crews consist of engineman, fireman, conductor, and three brakemen. Passenger crews consist of engineman, fireman, conductor, and two brakemen.

** Locomotive maintenance costs assumed on the basis of the best available experience that is believed credible.

efficiency. It is the hauling efficiency comparisons that are the epitome of most of the observations that can be made of the physical abilities of these locomotives. In addition to the inefficiency included in this comparison, steam locomotives spend sizeable portions of their useful lives engaged in the nonrevenue task of hauling their own fuel back and forth to various fueling stations. If this were measured easily it would impair still further the hauling comparisons with electric motive power which requires no allowance for such nonrevenue trailing loads.

## ECONOMICS

As stated earlier economic comparisons are difficult. Extreme variations in the physical conditions encountered make generalizations risky. Although it is impossible to analyze adequately economic factors surrounding the use of the locomotives described in the previous sections, it seems worthwhile to present some comparison in order to indicate the nature and general magnitude of the factors that affect the economics of motive power utilization at the present time and to suggest how changes in these factors could affect future comparisons.

*Hypothetical Operating Section.* A theoretical and over simplified 400-mile operating district of a mountain railroad was devised. Contrary to actuality, grades were assumed to be compensated equally in both directions (that is the summation of grade and curve resistance is

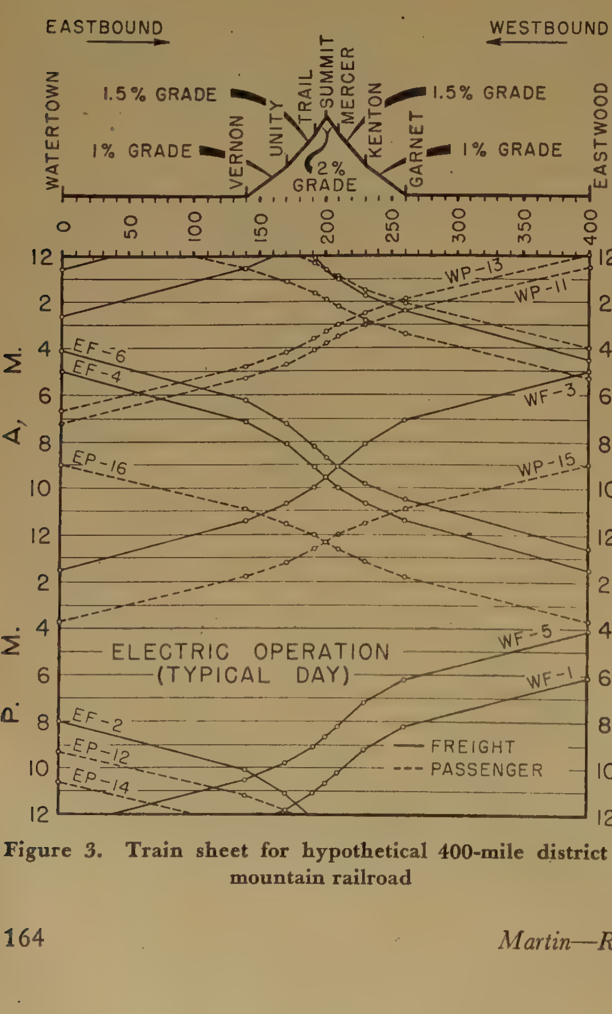


**Figure 3. Train sheet for hypothetical 400-mile district of mountain railroad**

**Table IV. Assumed Capital Cost of Facilities Affected by Type of Motive Power**

*400-Route-Mile District of Mountain Railroad*

| | Steam | Diesel | Electric |
|---|---|---|---|
| Electrification fixed properties | | | |
| 480 track miles of trolley and single phase transmission construction | | | $ 5,760,000 |
| Frequency changer apparatus and trackside substations | | | 3,650,000 |
| Communications and signal changes and other contingencies | | | 590,000 |
| Total fixed properties (electrification) | | | $10,000,000 |
| Motive power | | | |
| 15 (4-6-6-4) steam locomotives at $250,000 each | $3,750,000 | | |
| 11 Diesels at $600,000 (61,400 continuous rail horsepower at $107.49 per horsepower) | | $6,600,000 | |
| 9 motor-generator electric locomotives at $525,000 each (61,200 continuous rail horsepower at $77.21 per horsepower) | | | 4,725,000 |
| Total affected capital costs | $3,750,000 | $6,600,000 | $14,725,000 |
| Incremental investment over that required for steam operation | | $2,850,000 | $10,975,000 |

assumed to be constant to trains going in both directions). A sketch of the profile appears in Figure 3. No allowances were made for delays of any kind. Also no helper service was assumed. (Helper service is the addition of a "helper" locomotive to supply additional drawbar pull for exceptionally steep grades.) Each locomotive takes its rated tonnage (fixed by the 2.0-per-cent grade) and uses up any excess horsepower available on the lesser grades in additional speed.

A curious fact revealed here is that the tractive effort characteristics of the steam locomotive are such that when it is loaded to its maximum rated tonnage for the 2.0-per-cent or ruling grade it can run faster with that load on any lesser grade than the Diesel or electric locomotives can run with their rated tonnages. This does not mean that the steam engine can run faster with the same trailing load as is revealed by the average speeds attained by the passenger trains. It does mean that the steam locomotive in freight service can trail 1,500 gross tons over these 400 miles at an average speed of 51.9 miles per hour, whereas the Diesel and electric locomotives are able to handle their 2,280 and 2,850 tons at but 47.1 miles per hour.

Table II summarizes data necessary for calculation of operating expenses.

The principal comment that is required here relates to the rather remarkable savings in maintenance that are evident in the case of the electric locomotive. It seems to be true that on an equated rail horsepower–mileage basis, an electric locomotive of the type selected here can be maintained for from 40 to 50 per cent of the corresponding cost of a Diesel of the type selected. This can be explained quite well on the basis of the work necessary. The electrical and running gear maintenance of the two will be nearly identical. Maintenance of

the Diesel engine accounts for the chief difference. It can be seen that the difference in crew costs is purely a function of the relative hauling ability of the three types. Use of electric locomotives reduces the number of train miles that have to be run to a minimum that is nearly half that required by steam locomotives, and only about 80 per cent of that necessary for Diesel locomotives.

*Capital and Operating Costs Compared.* Table IV shows the assumed capital cost of those facilities which are affected by the type of motive power. Obviously these are only the costs of the items which would vary with the different types of motive power. Fixed properties appear only in the case of the electric. This is not actually true, but it is an assumption that works no particular hardship on the steam and Diesel locomotives. The prices that have been assumed like all prices in troubled times are subject to uncertainties, but the comparison between types of locomotives is believed to be realistic and fair.

**Table V. Assumed Annual Operating Expenses of Facilities Affected by Type of Motive Power and Effect of Changes in Price of Fuel and Energy**

| | Steam | Diesel | Electric |
|---|---|---|---|
| Operating expenses | | | |
| Maintenance of way and structures—Electrification fixed properties | | | 125,000 |
| Maintenance of equipment—Locomotive repairs | 1,397,220 | 1,084,050 | 560,640 |
| Transportation rail lines—Train crew expense | 1,620,280 | 1,165,080 | 989,880 |
| Fixed charges | | | |
| Depreciation | | | |
| Electrification fixed properties—$33\frac{1}{3}$ year life—3.0 per cent | | | 300,000 |
| Locomotives | | | |
| Steam, 25 year life—4.0 per cent | 150,000 | | |
| Electric, 20 year life—5.0 per cent | | | 236,250 |
| Diesel, $16\frac{2}{3}$ year life—6.0 per cent | | 396,000 | |
| Interest—Total affected investment—5.0 per cent | 187,500 | 330,000 | 736,250 |
| Total affected expenses except for fuel and energy | $3,355,000 | $2,975,130 | $2,948,020 |
| Fuel and energy expenses | | | |
| Case 1 | | | |
| 314,085 tons of coal at $2.00 per ton | 628,170 | | |
| 10,157,220 gallons of Diesel oil at 6.0 cents per gallon plus 20.0 per cent for engine lubricating oil | | 731,320 | |
| 159,191,100 kilowatt-hours at 4.0 mills per kilowatt-hour | | | 636,764 |
| Total affected expenses | 3,983,170 | 3,706,450 | 3,584,784 |
| Annual savings over steam operation | | 276,720 | 398,386 |
| Case 2 | | | |
| 314,085 tons of coal at $2.00 per ton | 628,170 | | |
| 10,157,220 gallons of Diesel oil at 7.0 cents per gallon, plus 20.0 per cent for engine lubricating oil | | 853,206 | |
| 159,191,100 kilowatt-hours at 4.0 mills per kilowatt-hour | | | 636,764 |
| Total affected expenses | $3,983,170 | $3,828,336 | $3,584,784 |
| Annual savings over steam operation | | $ 154,834 | $ 398,386 |
| Case 3 | | | |
| 314,085 tons of coal at $2.00 per ton | 628,170 | | |
| 10,157,220 gallons of Diesel oil at 7.42 cents per gallon, plus 20.0 per cent for engine lubricating oil | | 904,399 | |
| 159,191,100 kilowatt-hours at 4.0 mills per kilowatt-hour | | | 636,764 |
| Total affected expenses | $3,983,170 | $3,879,529 | $3,584,784 |
| Annual savings over steam operation | | $ 103,641 | $ 398,386 |
| Case 4 | | | |
| 314,085 tons coal at $2.50 per ton | 785,162 | | |
| 10,157,220 gallons of Diesel oil at 9.00 cents per gallon, plus 20.0 per cent for engine lubricating oil | | 1,096,980 | |
| 159,191,100 kilowatt-hours at 4.0 mills per kilowatt-hour | | | 636,764 |
| Total affected expenses | $4,140,162 | $4,072,110 | $3,584,784 |
| Annual savings over steam operation | | $68,052 | $ 555,378 |

Table V reveal that on the basis of present prices annual savings of $276,720 are possible where Diesels are substituted for steam locomotives at an incremental cost of $2,850,000 and annual savings of $398,396 are possible by electrification at an incremental cost of $10,975,000. With the 5.0-per-cent interest previously charged this is equivalent to returns of 14.7 and 8.6 per cent respectively on the incremental investments made for dieselization and electrification respectively. If this were all that could be said for the two alternatives it would appear that a case had been made for dieselization, for on this basis about a 6.0-per-cent greater return could be earned on money spent for modernization.

*Effect of Diesel Oil Price Changes.* That this would be a dangerous conclusion to reach hurriedly is evident upon examination of Table V where an attempt has been made to show how the annual savings of the different plans of operation are affected by changes in the price of Diesel oil and coal. Whether it should be assumed that Diesel oil will increase in price without assuming a corresponding increase in the price of coal can be debated. There are nearly as many opinions available on the future price of both commodities as there are authorities to be quoted. There does seem to be some evidence to suggest that the long term price trends of the two are different. The supply of coal though limited is fairly well known, while the supply of oil is both limited and unknown. It can be argued that both commodities are likely to increase in price with respect to their present bases but that the factor of increasing demand is more likely to produce a disproportionate increase in the case of Diesel oil. Demands for Diesel oil and all other petroleum products are increasing by leaps and bounds while the bituminous coal industry is organizing to combat what they view as the possibility of gradually decreasing demands.

*Electrification Offers Hedge Against Inflation.* It is believed that a substantial case for electrification can be inferred from these economic relations. The reasoning probably would be as follows:

1. The present attractiveness of Diesel-electric locomotives as replacements for steam locomotives has both a physical and an economic foundation.

2. Physically, the electric locomotive has no equal—there is nothing the Diesel locomotive can do to outclass the steam locomotive that the electric unit cannot improve upon.

3. Measured economically, dieselization has considerable present margin over steam.

4. Measured economically, electrification also offers a margin

over steam although the returns on incremental investments are not so large as offered by the Diesel on the basis of present prices.

5. The crux of the contest between dieselization and electrification lies in the question of which of the two is more likely to maintain or increase its present margin over steam, and this depends almost entirely upon the future price of respective energy sources.

6. The price of electric energy over the next decade or two may not decrease markedly, but it is hardly likely to rise. This largely is based on the fact that the supply can and very probably will keep pace with the demand.

7. There is no corresponding assurance of the maintenance of present prices for Diesel oil, and most authorities apparently anticipate gradual increases.

8. If the price of coal does not increase beyond present levels (in the view of many a strictly possible result of decreasing demand), an increase in the price of Diesel oil of 25 per cent approximately would equalize the return from investments in electrification and dieselization.

9. Should coal rise about 25 per cent in price a rise of 40 per cent in Diesel oil prices again would equalize dieselization and electrification.

10. In view of the foregoing, electrification appears to offer railroad managements the most likely hedge against inflation of operating costs. By electrifying main lines and dieselizing yard operations, it appears feasible for them to achieve some assurance of reasonable costs during the next 20 years.

# Southeast Power Pool

C. W. MAYOTT
MEMBER AIEE

**In 1941 a number of factors precipitated a power emergency in the southeastern portion of the United States, particularly in the states of Tennessee, Alabama, and Georgia, which, if permitted to get out of control, might have retarded the war effort seriously. To counteract this effect, a power pool was organized through the efforts of the Federal Power Commission and the Office of War Utilities which successfully met the demands of the situation, as well as providing experience which proved to be of great value in co-ordinating the power supply of the United States throughout the war.**

THE 1941 power emergency in the southeastern section of the United States covered principally the states of Tennessee, Alabama, and Georgia, and was caused by a number of factors. While it was inconvenient for the people of the area, for many industries classed as nonessential, and for the power suppliers, it did not retard the preparedness program or the war effort. On the contrary, the lessons learned during the emergency were later of great value to the Power Division of the Office of War Utilities in co-ordinating the power supply of the United States.

## BASIC CAUSES

The immediate cause of the emergency was a combination of low rainfall and a great increase in load, principally aluminum, for the preparedness program. The basic cause, however, went back to previous years. Low rainfall is not an unusual occurrence. Experience has taught all power companies with hydro development that steam reserves must be available for such an uncertainty if continuity of service is to be maintained. This was well understood by Georgia and Alabama power companies. However, a number of factors retarded their power development very seriously during the 30's. These factors were the threat of subsidized government competition, the possibility of losing more of their systems (the Tennessee Valley Authority did take over the Tennessee Electric Power Company) and the uncertainty of bureaucratic action under the Holding Company Act of 1935.

Other sections in the Southeast not so closely affected by these conditions were not so retarded and, as shown later, were able to take care of their own systems during the 1941 period as well as to aid the Tennessee, Alabama, Georgia area.

The TVA was built up as a hydro system, and, although it did acquire some 200,000 kw of steam capacity with Muscle Shoals and with the Tennessee Electric Power Company system, its plan of operation did not call for steam generation. Contracts with large electrometallurgical and electrochemical companies were on the basis of hydroelectric power only and permitted the

Essential substance of a report presented at the AIEE North Eastern District meeting, Buffalo, N. Y., April 24–25, 1946.

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shut-down of industries for about two months each year during the low water period.

The need for more base steam capacity apparently was realized by the TVA in 1940 for at that time it asked the Congress of the United States for an additional steam plant in the interest of national defense, and on July 31, 1940, authority was granted to construct it. This steam power plant, known as the Watts Barr steam plant, now has four units of 66,000 kw capacity each. None of this capacity was available, however, in 1941.

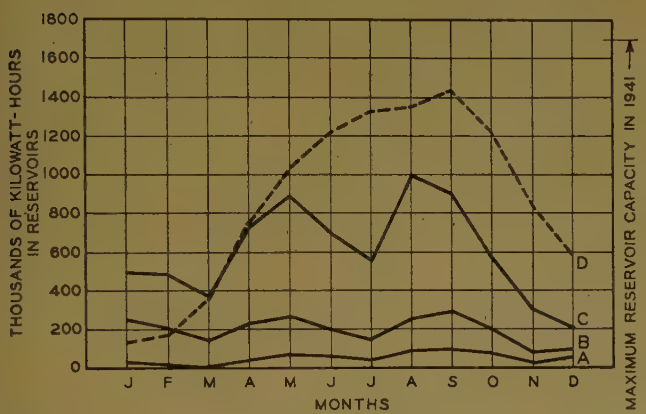


**Figure 1. Energy in reservoirs of southeastern area in 1940 and 1941**

*A—Aluminum Company of America*
*B—Commonwealth and Southern Corporation*
*C—Tennessee Valley Authority, total for 1941*
*D—Tennessee Valley Authority, total for 1940*

In addition to the Watts Barr steam plant with a total 264,000 kw the United States Army installed a 250,000-kw steam plant at Oak Ridge, Tenn., to carry part of the atomic bomb load. This now provides more than 700,000 kw of steam capacity in TVA territory. The interconnections can supply approximately 400,000 kw more.

In 1941 aluminum production had to be speeded up to maximum output. Regardless of contracts, the necessary power had to be delivered to the aluminum plants to accomplish this.

## LOW WATER

1941 was also one of the minimum water years in the Southeast. Precipitation in the Tennessee and neighboring basins had been far below normal since the fall of 1940. This same condition prevailed throughout the country east of the Mississippi River.

Under the authority granted by the Utility Act of 1935[1] the Federal Power Commission considered the situation in the Southeast an emergency and took control in May 1941. At a hearing held in Washington, D. C., during that month to check the amount of assistance the neighboring companies were giving and could give, the TVA representative stated that all companies had been co-operative. It was brought out that the following new capacity was to be available within the shortage area:

| | |
|---|---|
| Georgia Power Company, Macon, Ga. | 40,000 kw steam expected in June 1941 |
| Alabama Power Company, Mobile, Ala. | 40,000 kw steam expected in July 1941 |
| Aluminum Company of America, Glenville, N. C. | 20,000 kw hydroelectric power expected in August 1941 |
| Georgia Power Company, Atlanta, Ga. | 60,000 kw steam expected in October 1941 |

This was in addition to other new steam capacity under construction in the surrounding territory.

In June 1941 a voluntary curtailment program was put into effect during which the additional new steam capacity was of assistance. Rains during July gave sufficient relief to allow the customers to go back to normal use.

## FPC DIRECTIVES

The FPC issued a directive ordering prompt construction of seven new lines which they claimed would make available 200,000 kw more capacity to the area within six months. A list of these lines is given in Table I together with the time they were put into operation.

Two of the Georgia–Florida lines (items 4 and 5 of Table I) were put in operation in 1941. The capacity

**Table I**

| Item | Company | Location | Date Put Into Operation |
|---|---|---|---|
| 1 | Florida Power and Light Company—Florida Power Corporation | Sanford to Benson Springs, Fla. | 1-3-42 |
| 2 | Duke Power Company and Carolina Aluminum Company | Albermarle to Badin, N. C. | 7-25-41 |
| 3 | New Orleans Public Service, Inc., and Mississippi Power Company | New Orleans, La., to Gulfport, Miss. | 3-4-43 |
| 4 | Georgia Power and Light Company and Georgia Power Company | Waycross to Alma, Ga. | 10-13-41 |
| 5 | Florida Power Corporation—Florida Power and Light Company | Jasper to Lake City, Fla. | 12-10-41 |
| 6 | Florida Power Corporation—Georgia Power Company | Jasper, Fla., to Tifton, Ga. | 3-2-42 |
| 7 | Florida Power Corporation—Alabama Power Company | Pinckard, Ala., to Quincy, Fla. | 8-25-42 |

available to these lines was very small and of little value during the emergency. The other Florida lines also were of no value during the emergency but they were valuable in protecting and carrying some of Florida's load from Alabama and Georgia during the war.

The connection between New Orleans, La., and Gulfport, Miss. (item 3), which first was used March 4, 1943, required very expensive construction through swamps and forests. It electrically parallels the lines

through Memphis to Mississippi and Arkansas. The transfer over it (maximum test transfer has been 30,000 kw) was not independently controllable and there was little surplus capacity available at either end of the line. The material and labor used in its construction would have contributed much more to the war effort if used in other places.

### AID BY POWER COMPANIES

Item 2 of Table I, the Duke Power Company, was for additional line capacity. The Duke Power Company, The Carolina Power and Light Company, and the Carolina Aluminum Company long had been co-operating on their power supply. A contract in effect which was made long before the emergency provided for 50,000 kw of capacity from the Carolina Aluminum Company to the Duke Power Company when the latter requested it. The energy with this demand was 3,300,000 kilowatt-hours per month. In spite of this contract the Duke Power Company was furnishing the aluminum company preparedness emergency power starting in 1940 as follows:

| | |
|---|---|
| November 1940 | 9,400,000 kilowatt-hours |
| December 1940 | 11,500,000 kilowatt-hours |

Average delivery to the Carolina Aluminum Company during the first seven months of 1941 was 15,800,000 kilowatt-hours per month with a maximum of 17,700,000 kilowatt-hours and a minimum of 10,800,000 kilowatt-hours.

The 6.3 miles of new line ordered was constructed in a very short time and furnished additional aid to the aluminum company. Delivery for the last five months of 1941 was as follows:

| | |
|---|---|
| August | 21,300,000 kilowatt-hours |
| September | 22,300,000 kilowatt-hours |
| October | 23,900,000 kilowatt-hours |
| November | 33,400,000 kilowatt-hours |
| December | 36,700,000 kilowatt-hours |

Tennessee, Alabama, and Georgia reservoir elevations were fair on August 1 and on September 1. With the low rainfall, however, they dropped quickly during September and October as shown in Figure 1.

After additional hearings, on August 19 docket *IT 5727* was issued requiring that private companies rather than the co-operative construct the interconnection between the Alabama Power Company at Pinckard and the Florida Power Corporation at Quincy.

On October 21 docket *IT 5740* was issued on the Duke Power Company to make specified deliveries. As previously noted, this company had begun to help its neighbors during the previous year. Its development had not been affected detrimentally as had the Georgia and Alabama companies, and so it was prepared to carry its own load under the most adverse water conditions as its steam reserves were ample. With these steam reserves it had started to conserve its hydroelectric power early in the year and thus kept its reservoirs up for emergencies. This "bank account" was called upon to give additional help to TVA, Alabama, and Georgia, as the power situation in the area became increasingly worse. The rate of reservoir draw-down indicated empty reservoirs by the early part of December 1941. Arrangements therefore were made with the Office of Production Management to have its Power Branch take over.

### DIFFICULTIES OF THE FPC

For the FPC it may be stated that it is supposed to be primarily a regulatory body but it has had a number of other functions tacked onto it. The emergency authority

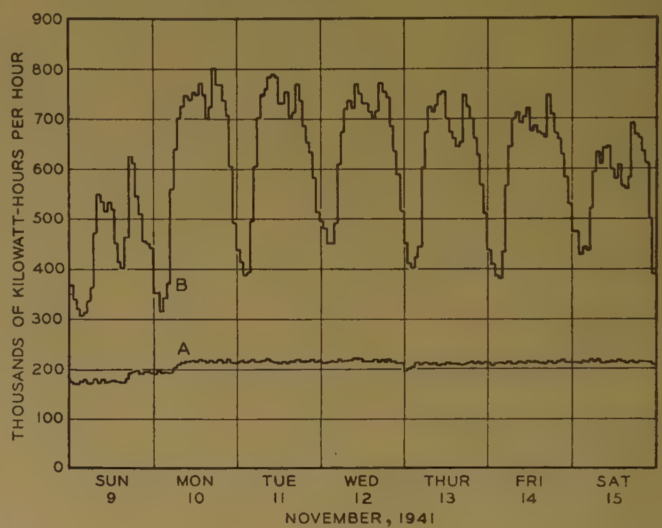


**Figure 2. Tennessee Valley Authority hourly generation for a week in November 1941**

*A—Fuel generation B—Hydroelectric generation*

is one of them. The problems presented by the Southeast emergency required a very different approach than the FPC had used in its previous activities. In addition, when it became necessary to consider compulsory discriminatory curtailment, the FPC did not have the proper authority.

J. A. Krug, who was in charge of the Power Branch,* was directed to take command of the situation. After consultation with state officials, the FPC, and the power men, he built up an organization to handle co-ordination, curtailment, and enforcement. This organization was made up of personnel who had had experience with the particular problems they were to handle. They were taken from power companies, TVA, the Power Branch, and the public utilities commissions of the states involved. The direct interest of the state governments was recognized by placing representatives of the utility commissions in key positions where they gave

* The Power Branch of the Office of Production Management (changed to War Production Board) which later became the Office of War Utilities.

valuable assistance. (The author was selected to supervise power co-ordination because of his operating experience, particularly as manager of the Connecticut Valley Power Exchange for 16 years.)

To be prepared for any eventuality the OPM issued limitation order *L-16* dated October 30, 1941. The only other order issued was supplemental order number 1, dated November 6, 1941. This was at the request of the utilities in North and South Carolina and Virginia as a legal protection against possible default of their contracts because of their co-operation in the emergency.

Headquarters were set up in Atlanta, Ga., and on November 3, 1941, the FPC issued docket *IT 5742* for the delivery of power to the ferrous-alloy furnaces at Charleston, S. C. These furnaces were located so as to use Santee Cooper power when it became available, but had to be carried by the interconnected systems in the meantime. Curtailment was ordered of industries considered not absolutely essential to the preparedness program, also of commercial and some other uses. It was in effect from November 17 to December 5.


**Figure 3. Sources of assistance for power shortage area**

*Width of arrows indicates volume of power transfer as additional power is picked up along the line*
*Figures show kilowatt-hours of power each arrow brings into area per week*
*Shaded part indicates shortage area*
*All states through which arrows flow contributed to power pool*

## POWER BRANCH RULES

The Power Branch instructions to its personnel were quite simple but quite explicit. We were to co-operate with the people in the Southeast. No partiality was to be shown. Only such orders were to be issued as were absolutely necessary. On that basis we were to help the Southeast resolve its power difficulties and then turn control back to the local area.

When we took over near the end of October, the rate of reservoir drawdown in Tennessee, Alabama, and Georgia, if continued, would have emptied essential reservoirs by the first week in December. This, of course, would have meant drastic curtailment.

## PROBLEM

Our first problem was to get maximum steam generation within the area and maximum transfer into the area. This, like all such problems, required not only engineering knowledge, but operating experience, and an understanding of human relationships.

We held several group conferences during the first week. At first we followed the established procedure of having the government representatives on a raised platform facing the men with whom we were conferring, but as soon as possible we instituted round table conferences which proved more profitable.

We outlined the situation as of that time and told what we hoped could be done. Then we asked the group to discuss the problem among themselves and to let us know the maximum they could do. With the knowledge that they would have our full legal and moral backing, each group voluntarily agreed to set up its own control organization and to see that maximum chances were taken to get greatest possible deliveries into the area.

## OPERATION

All possible steam generation was obtained within the area. Units as low as 200 kw were pressed into operation. The incremental cost at some of these plants ran up to over five cents per kilowatt-hour.

Steam was run on base load. As an example of weekly operation, Figure 2 shows the TVA's generation by the hour for a week in November 1941. It will be noted that the steam generation hardly varied for that period. The hydroelectric power in that system had to take part of the base and all the variation. In the Duke Power Company steam took care of the full base load with

hydroelectric power taking the variations except for the low load periods at the week end. The Duke company's operation was typical of the power companies with hydro capacity.

Outside of the Tennessee, Alabama, Georgia area, and the North and South Carolina and Virginia area, hydroelectric power was a very minor factor. The 1941 ratio of steam to hydroelectric power within the two aforementioned areas is given in Table II.

The shortage was in energy, not capacity. There was a large surplus of hydro capacity for very short time use. Such operation, of course, used up available water but it did allow the loading of ties beyond their normal capacity. When the tie loading did pass the stability limit and trip, the hydroelectric power could pick up the load long enough to bring the frequency to normal so the systems again could be paralleled. The tie through Waterville, N. C., to the American Gas and Electric Company through to the north central section of the United States was a good example. This tie tripped several times each day. When it tripped the Carolina Power Company's Waterville plant would pick up the load, which sometimes was as high as 70,000 kw, bring the frequency together, close the line, and then drop its load to minimum. Many times this whole cycle of operation was performed in about a minute. Another tie that tripped frequently was that connecting Arkansas to Tennessee (Figure 4*B*). Others tripped, but not so frequently.

**Table II. Summary of Capacities in the Southeastern States**

| | Hydroelectric (Thousands of Kilowatts) | Power Steam (Thousands of Kilowatts) | Total (Thousands of Kilowatts) | Hydroelectric Per Cent of Total |
|---|---|---|---|---|
| Tennessee Valley Authority | 835 | 215 | 1,050 | 79.5 |
| Commonwealth and Southern Corporation | 694 | 311 | 1,005 | 69.0 |
| Aluminum Company of America | 373 | | 373 | 100.0 |
| Duke Power Company | 462 | 400 | 862 | 53.6 |
| Carolina Power and Light Company | 195 | 43 | 238 | 82.0 |
| Others | 130 | 390 | 520 | 25.0 |
| | 2,689 | 1,359 | 4,048 | 66.5* |

* National figures are 28 per cent.

## SOURCES OF ASSISTANCE

The chart in Figure 3, made in November 1941, shows the deliveries of energy from 13 states into the shortage area for a week. It indicates approximately the source and path. This chart does not show the emergency deliveries to the Carolina Aluminum Company at Badin, N. C.

Power was delivered from Virginia, the Carolinas, and Florida; from Texas, Louisiana, Mississippi, and Arkansas; from Chicago, Ill., and Pittsburgh, Pa., and down through the north central states. This emergency power was billed at cost. The generating company added ten per cent for line losses, as did each transmitting company. As this power all was superimposed to maximum line capacity on the regular loads, ten per cent was probably a conservative figure. The companies in Alabama and Georgia of course had to absorb these emergency costs. The TVA could pass them on to the Aluminum Company to keep from distorting its bookkeeping.

As stated previously, these companies had been co-operating before the federal government entered the picture. The Power Branch was called in when the greatest co-operative co-ordination and curtailment had become necessary. By this co-operative co-ordination we were able to get over 42,000,000 kilowatt-hours per week into the area whereas 32,000,000 kilowatt-hours per week had been the previously predicted maximum.

As co-ordinator we had to keep everyone informed as to what was happening, immediately straighten out any misunderstanding that might arise, keep records of the operations, hold conferences, and so forth. Co-operation enabled us to do this part of the job with three men and a typist.

## RESULTS

The rains started by the last part of November. This, with the additional deliveries we had been able to provide for the area, relieved the situation so that curtailment could be discontinued by December 5, after about $2^1/_2$ weeks. Mr. Krug made this decision at the earliest possible moment. Soon after, the entire organization, with the exception of the co-ordinating group, closed up shop and left. The co-ordinating group was kept functioning for a period to be sure no unforeseen difficulty should arise. Its services were terminated as of January 5, 1942. This in itself was a notable event. Many government people considered it with amazement, some with consternation, for here was a federal agency that voluntarily relinquished its control at the earliest possible moment.

Although the load in the area continued to rise throughout the war, new facilities were approved and installed in sufficient quantities to take care of the situation. The co-operative co-ordination has continued to be excellent, and we have experienced no further power difficulties in that section.

The results of our operation in the Southeast had much to do with our continuing in control of power throughout the war. The experience gained there had much to do with our way of handling the power supply during the war.

As "Cap" Krug has boasted, rightfully, about that period:

> Power has never been too little or too late.

## REFERENCE

1. Utility Act of 1935, part 2, section 202.

# A Quarter Century of Electronics

I. E. MOUROMTSEFF
ASSOCIATE AIEE

**This brief outline of the main consecutive stages in the development of high-vacuum electron tubes during the last quarter century is presented from the viewpoint of a large electrical manufacturing company. The outstanding problems of early research and development viewed in retrospect well may serve to refresh the memory of the readers.**

SPURRED by war demands, a tremendous progress in the field of electronics took place during the strenuous five or six years of the recent war. In peacetime surrounding, the same progress admittedly would require a much longer period. However, one is justified in the assertion that all brilliant war achievements were deeply rooted in the previous peacetime work of many individuals and organizations; brick by brick they accumulated fundamental knowledge, experimental material, and many practical accomplishments from which at the time of emergency the grandiose building of war electronic applications could be built, mainly, by using lavishly the cement of gold and the concerted efforts of a great number of American engineers and scientists. As for the electron tube—the heart and soul of every electronics project—basically, all types of electron tubes used in war had been known and already had reached a stage of considerable development by the time the war began.

## EARLY DAYS OF ELECTRON TUBE APPLICATION

The coming of the high-vacuum electron tube, some 40 years ago, was not greeted with overwhelming enthusiasm by radio specialists. In fact, for almost 15 or even 20 years after the invention of the high-vacuum electron tube it had to compete in the field of radio reception with the simpler and much cheaper crystal detector and with some other devices.[1] Even the early discovery of the amazing property of the electron tube to generate continuous oscillations of any desired frequency was not eagerly seized upon by radio engineers; in fact, for another decade they continued to look for the solution of long-distance radio-communication problems in the improvement of high-frequency alternators, in designing bigger and better spark-gap transmitters and Poulsen arc generators. The electron tube was recognized without competition only in the field of the long-line telegraph and telephone repeaters; also, it found application, on a limited scale, in very short distance radiotelephone communication for military and navigational purposes prompted by World War I. Restriction imposed by patent rights, lack of stimulating commercial interest, and distrust of the reliability of the new device were the obstacles to its more rapid development and wider practical application.[2] During this period it was discovered that for an effective controllable operation of the tube, a good vacuum was quite necessary. This fact stood in contradiction to the early beliefs in the mysterious role of the residual gas. However, the actual impetus to the development and progress of the high vacuum electron tube was given by the advent of radiobroadcasting.

*An Important Event.* The possibility of receiving a radio message without the sender's knowledge was at all times a natural privilege of anyone who had a suitable radio receiver located within the reach of the transmitter "radiating" the message into space. But, this possibility was considered to be a nuisance rather than an advantage of radio as it deprived communication of secrecy and privacy. Obviously, this inherent property of radio communication did not yet constitute the art of broadcasting, as one readily can conclude from the contemporary technical literature. The true art actually was born on November 5, 1920, when Frank Conrad, an engineer of the then Westinghouse Electric and Manufacturing Company prearranged a systematic broadcasting by *KDKA* of the results of the presidential election (Harding versus Cox).[3] Music and other entertainments filled the gaps between the individual shots of election returns[4] (Figure 1). But even this very fact would not have created the art of broadcasting had not a similar procedure continued every day on a regular schedule, and had not H. P. Davis, inspired by the reaction of the broadcast audience, immediately decided that this could be made a new art. He realized that it could be turned into a permanently useful institution on a wide scale, not only for the sake of the fun of a few radio fans but to serve important commercial, educational and cultural purposes of the whole nation.[5] The subsequent rapid development of radiobroadcasting aroused a wide public interest in radio and indirectly played an important role in the revival of business in general from its stagnancy in a postwar depression. A period of rapid development of many new types of electron tubes to suit the variety of the new demands brought about by the nascent art was inaugurated.

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## ELECTRON TUBES FOR BROADCAST RECEIVERS

In close connection with the new art of broadcasting, the *WD-11* and *WD-12* tubes were developed. At that time several types of radio receiving tubes were already in existence. In addition to the original DeForest Audion, popular among amateurs, several improved types were developed during the war by several large concerns for the government. As a consequence of the war experience, the Westinghouse Bloomfield Lamp Works manufactured in 1919 so-called "aeriotron" tubes, types *WR-21A* and *WR-21D* on a limited scale. But in general the postwar years up to the beginning of the broadcasting era were a dull period in the history of the electron tube business. In order to remove the competition among the radio manufacturers and stagnation caused by patent barriers, in October 1919 the Radio Corporation of America was formed, unifying several concerns commercially interested in radio. At the time of the formation of RCA, radiobroadcasting did not exist, and therefore the concerns constituting RCA realized that other than commercial communication, which was largely of a transoceanic nature, the only business for RCA could be selling radio apparatus, parts, and tubes to a group of amateurs and radio experimenters, of which there were probably about 5,000 in the whole of the United States.

All previously developed receiving tubes were so designed that their filaments had to be operated from a 6-volt storage battery (*A* battery) requiring attention and frequent charging, and also incurring waste of power in a series resistance. In close connection with the broadcast experiments and in anticipation of the needs of the numerous listeners, Conrad conceived an idea of a tube the filament of which could be heated from a single standard dry cell; this, of course, should be a blessing to listeners. Such a tube was designed with an oxide coated filament. Oxide coating was a familiar feature with most of the early tubes (Wehnelt cathode), and was used successfully by the Western Electric Company for telephone and telegraph repeater tubes. The new aeriotron tube, the *WD-11* type, called a "peanut" tube,[6,7] required for its filament operation only 0.25 ampere at 1.1 volts (Figure 2). For several years *WD-11* had practically no rivals.

A greater demand for electron tubes caused by the birth of broadcasting was answered by general efforts of all tube manufacturers to improve the tubes in every possible respect. Thus, as early as 1921, an idea was conceived to simplify tube operation by complete elimination of the *A* battery. As a result, detector and amplifier tubes were designed for a-c operation of the filament.[8] The idea was simple, almost natural, but no prior attempts had been made by anyone to apply it to small detector and amplifier tubes. It had been taken for granted that as a result of the alternating potential difference along the filament surface and of the a-c

**Figure 1. Frank Conrad with the original KDKA equipment**

magnetic field in the vicinity of the filament surface, the 60-cycle a-c noise would be originated by the filament and amplified together with the useful signal, to the detriment of clear reception. However, it was demonstrated that there was a possibility of avoiding the a-c noise by the construction of an indirectly heated cathode in which the a-c heater wires were buried inside a cylindrical porcelain body, the surface of which served as a unipotential cathode. Barium-strontium oxide coating was applied to it. Later on, even a "rough" filamentary cathode type was developed with an oxide coated ribbon filament, which also could be operated from an a-c supply with quite satisfactory results.[9] The new designs seemed at that time so unconventional that, for several years, these tubes met with a great deal of opposition. In 1927 two types of such tubes finally were adopted by RCA for the standard a-c operated Radiola-*17* under the designation of *UX-226* (rough filament amplifier) (Figure 3) and *UY-227* (indirectly heated detector tube). In addition to a-c operation, these tubes, because of the large oxide-coated cathode surfaces, had higher transconductance and were capable of giving higher current and greater output than any other equivalent tube.

Tubes with oxide coated cathodes, in general, were favored by the Westinghouse designers.[10,11] In the earlier days (1921) a special "wet" method of coating was developed but later it was replaced by the "spraying" method. The general advantage of the oxide coated cathode in receiving tubes is the low operating temperature and low heating power combined with a large emitting surface. Another example of an oxide-cathode tube which has been used widely is the *UX-250* "power output" tube adopted in 1927 for loud-speaker operation.[12] It was capable of furnishing 4.65 watts output which at that time exceeded by four times other standard tubes designed for the same purpose.

Still another contribution was the *UX-280* full-wave high-vacuum rectifier twin tube[13] which could supply twice as high a current as its predecessors. This became important with the introduction of all a-c operated radio sets.[14] The *UX-280* had unusually long life, not only because of its improved cathode, but also because of a new method of "carbonizing" anodes making them permanently black (not peeling off). This method has since been adopted and used in manufacturing with the majority of receiving tubes. The *UX-280* was the progenitor of a long line of oxide-coated-cathode rectifier tubes designed to have various characteristics.

## TRANSMITTING TUBES

*First Water-Cooled Tubes.* Attempts, more or less successful, to transmit the human voice over the air had been made from the early days of radio. Poulsen generators, mercury arc tubes, and high-frequency alternators were tried out for this purpose. However, full practical realization of radiotelephony became possible only with the appearance of transmitting electron tubes capable not only of generating high frequency power but of controlling it with great precision.

Radiobroadcasting added enormously to the importance of radiotelephony and brought about an immediate demand for larger tubes with more power. It may be of interest to note that the original broadcast was made with only two "50-watters." It had become obvious that tubes with high-frequency power output measured in kilowatts soon would be necessary.

It was also obvious that this could be achieved only with the external water-cooled copper anodes permitting tube operation at higher voltages and heavier current. The main problem in constructing such tubes was a reliable vacuum-tight metal-to-glass seal between the anode and the glass envelope supporting and insulating the internal tube structure. This problem was solved (1922) by Housekeeper by his well-known tapered knife-sharp anode edge to which glass could be sealed securely. Very soon water-cooled tubes of 10 to 20 kw rating were produced by all tube manufacturing concerns.[15] The *WO-41* and *AW-100* types[16] (Figure 4) originally were intended only for *KDKA* and her sister broadcast station *KFKX*, at Hastings, Nebr. It was not anticipated at that time that the future needs in water-cooled tubes might exceed more than a few tubes per month.

The modern electronic engineer hardly can imagine all the obstacles involved. For example, one of the main difficulties was preparing vacuum-tight copper shells for the anodes. To draw anodes to precise dimensions—now the common practice—was simply impossible at that time; experiments in this direction were too expensive and unwarranted by the immediate volume of business; spinning proved to be too inaccurate, lengthy, and difficult; finally, making anodes from solid copper bars by drilling, to which "tapered skirts" had to be attached by brazing, invariably resulted in "slow

**Figure 2. WD-11, the first dry-cell receiving tube**

leaker" tubes with very short shelf life. The art of brazing, so freely used now in tube structures, was not yet developed to the present level of perfection.

Another general impediment was glass-blowing work on water-cooled tubes. Glass-blowing was looked upon at that time as a real art and a mysterious one. For a decade or longer no machine tools were used even by large tube manufacturers. All work was done by the hands of very skillful glass-blowers. The salary of a good glass-blower—and there were very few of them available—by far exceeded that of a good engineer. The tube designer was frequently subject to a great degree to his glass-blower's whims. Many things which now constitute everyday practice were pronounced impossible by specialists and could not even be tried. This situation gradually changed as a new generation of domestic artisans was educated. On the other hand, requirements for large and heavy tubes forced tube manufacturers into designing and using glass-blowing machines; this permitted training even unskilled workers to perform successfully many glass-blowing operations.

In many other respects experience in making large electronic tubes had to be acquired slowly. At the beginning a tube designer was supposed to know only his "electronics." Now designing of a good tube requires the application of mechanical, chemical, metallurgical, ceramic, hydraulic, and heat engineering.

The original *WO-41* and *AW-100* tubes with some modifications became the modern standard *207* type with its several derivative tubes, such as the *891* and *892*. They are used widely in radio and industry and now are manufactured by many concerns.

*The "100-Kw" Tubes.* Toward the end of the 1920's the number of broadcast transmitters was increasing gradually and so was their power output. In order to avoid mutual interference, a limit was put by the government on the transmitter power at 50 kw carrier power. With 100 per cent modulation it re-

quired 200 kw instantaneous power output from the tube complement. This required at least six tubes of the *207* or similar type. Therefore larger tubes were necessary so that two of them in a push-pull arrangement could take care of the whole power output without the discontinuities of service caused by frequent replacement of one or more of the paralled tubes. A tube with 100 to 200 kw output was designed and designated the *AW-220.*[17] It was used for some time by *KDKA* when it was located at Saxonburg, Pa.[18]

However, the *AW-220* finally was replaced by the *UV-862* tube adopted by mutual agreement of the members of the Radiotron Standardization Committee, because of its simpler design and lower cost of manufacture. Nevertheless, the *AW-220* had several valuable design features which were utilized later on in several modern tubes of various makes. Thus, for example, the *AW-220* had a water-cooled grid, a feature which was introduced as a result of experimentation with larger tubes of some other obtainable designs. Some individual tubes would run away at lower than rated voltages, because of the excessive heating of the grid by impinging electrons.

Another interesting feature was the pioneered use of solid helical tungsten springs. There was one heavy helical spring made of $^1/_8$-inch tungsten rod designed for expanding the whole filament structure when filaments were heated, and eight smaller helical springs to take care of the differential expansion of the individual filament strands and to keep them taut exactly in their prescribed positions. New methods of winding and of preseasoning the springs were developed.

Finally, a fluted copper anode was used to increase the rate of cooling the tube and to provide for precision spacing between the large jacket and anode.

*Tube Characteristics Charts.* Strange as it may appear now, for almost 15 years transmitting tubes were manufactured, sold, and operated all over the world without a complete knowledge of their characteristics and without means of accurately predicting their performance, except by the cut-and-try method. The manufacturers usually prepared and supplied the "lower part" of the familiar modern transconductance and plate current–voltage static characteristics. The curtailed type of charts was inherited from the receiving tube practice. But what was entirely satisfactory for figuring out performance of a receiving tube was entirely inadequate with the transmitting tubes. Such characteristics could be utilized by the transmitter designers only for precalculation of inefficient class-*A* operation, such as was in universal use for audio-modulation in the transmitters of the early years, operated as self-oscillators (up to 1926), or class-*C* amplifiers. Analytical methods for precalculation of tube performance, though proposed early, could give only an approximate solution and only for a steady state of operation, and could not be applied successfully to a modulated operation.

**Figure 3. UX-226, the first a-c receiving tube**

In order to help the tube manufacturer to know his own tubes and in order to relieve the work of the transmitter engineer, a method was developed for preparing the so-called "complete" tube characteristics charts.[21] These presented plate and grid currents up to the highest values feasible in operation and by far exceeding those that could be recorded by the static observation previously used. The new method can be described as a single capacitor discharge through the tube with simultaneous recording of instantaneous tube currents and voltages by means of a multielement oscillograph.

The complete charts permitted graphical solution of many problems of tube operation by plotting all kinds of dynamic (or operating) tube characteristics for any set of preconceived quiescent operating conditions. From these tube output, driving power, and efficiency could be calculated.[22,23] Now for the first time, the tube manufacturers could publish systematically precalculated operating data and definite limitations for their tubes; also, the designer could explore the tube possibilities before he built his circuit and could choose the best operating conditions for his specific problem.[19,20]

It may be noted that in close connection with the development of the method for plotting complete tube information, the so-called *constant-current charts*[24] of tube characteristics were put into practice. It was found that they were specifically adaptable for precalculation of class-*C* amplifier and self-oscillator performance.

In the rapidly progressing art of electronics ten and even five years are a long time. With the great improvement of the cathode ray oscillograph—which was brought about by the young art of television—it was obvious that the new device with certain advantages could replace the multielement string oscillograph in the original capacitor-discharge method, just described. Also, use could be made of the greatly improved mercury vapor tubes (thyratrons, ignitrons) for precision control of heavy instantaneous discharge currents. As a result, several modern modifications of plotting complete charts

made their appearance, some of them not yet published.

## TUBES FOR SHORT AND ULTRASHORT WAVE OPERATION

*Tubes in Short Wave Operation.* During the 1920's radio specialists gradually realized that for bridging over large distances by radio relatively small transmitters emitting short-waves (waves shorter than 100 meters) could compete successfully with the huge long wave transmitters. An important role in this realization was played by American and British amateurs who were driven by the government regulations into the good-for-nothing short-wave band. Among strong advocates of short waves was also Frank Conrad who at an early date experimented with 60-, 40-, and 20-meter transmitters,[25] and for this work received the Morris Liebmann Memorial Prize, 1925. All experimenters were using standard tubes in their short-wave transmitters. Thus, in 1926, a pair of *AW-100* tubes (later on specified as *UV-207* tubes) were run successfully at 14-meter wave length in the first experimental RCA transmitter at Rocky Point, N. Y.

*Industrial and Television Ultrahigh-Frequency Tubes.* Partly because of the general demand for short wave tubes, partly because of the nascent arts of television and frequency modulation based on ultrahigh-frequencies (greater than 30 megacycles), the tube designers in the early 1930's became ultrahigh-frequency minded. The *AW-200* (now *WL-899*) tube was of a peculiar double-ended structure.[26] This tube, in a circuit consisting of a portion of concentric transmission line (the first example of such a circuit), could produce from 10 to 20 kw at 60 megacycles. It was used in many early (1930–1934) and successful experiments on dielectric heating.[27] Although heating of dielectrics by high-frequency electric fields was known as a nuisance for many years, this seems to be the first constructive attempt of its practical utilization in industry. Because of the high cost of the necessary equipment and of the ravaging depression, further experiments were discontinued, and the tube was shelved and forgotten.

However, when RCA television designers, two or three years later, started to look for an ultrahigh-frequency tube suitable for their first 10-kw television transmitter they could not find anything but the *899* tube. Around this tube the first powerful television transmitter on the Empire State building actually was constructed. Modern television, in its present basic form with the cathode ray tubes as the heart of the receiver and of the transmitter, was originated by V. K. Zworykin who made preliminary experiments in this direction at the Westinghouse research laboratories at East Pittsburgh, Pa.[28–30] The *WL-899* and its modification, the *899A*, later on (1938) proved to be suitable for frequency-modulation broadcast transmitters.

*The Magnetron.* The period of the 1930's truly can be called the era of ultrahigh-frequency developments. First, television; then, frequency modulation; finally, radar—all demanded high power tubes which could be operated at frequencies from 30 to 100 megacycles per second and even higher. Although several types of ordinary 3-electrode tubes had been developed for these purposes by various designers, great attention nevertheless was paid from the beginning to the split-plate magnetron. This interest was stirred up by two Japanese professors, Yagi and Okabi, who in 1928 noticed that this type of magnetron was capable of generating oscillations of extremely high frequencies, up to several thousand megacycles, although power output was small. Magnetrons for 30-, 20-, 10- and even 2-centimeter waves were constructed. In this work a discovery was made that, if the electrons wheeling around within the anode are permitted to drift in the axial direction toward the anode ends, power output could be increased considerably. Thus with a 10-centimeter magnetron it was possible to produce for the first time power of 1 or 2 watts.[32] With this tube and parabolic mirrors beam communication was demonstrated on October 14, 1931. A complete beam equipment was exhibited and demonstrated at the Chicago World's Fair, 1933–34. Several similar equipments were furnished to Naval Research Laboratory and to the Signal Corps, who at that time were at the beginning of their experimenting with radar with all sorts of systems.

*The First High-Power Radar Tube.* In 1937, the Signal Corps completed their experiments with the first practical radar system, employing 16 small tubes of the standard type *VT-127A*. It now was desired to have tubes with much greater output and longer life than could be obtained from the relatively small tubes of the original transmitter.

The problem was solved with the results considerably exceeding all expectations. Tube life of the *WL-530*[33,34] from the start was several hundred hours, and instantaneous power output was from 75 to 100 kw. In order to provide for instantaneous tube current up to 75 amperes, an abundant thoriated filament of a self-supporting bird-cage type was incorporated. It seems that the *530* tube

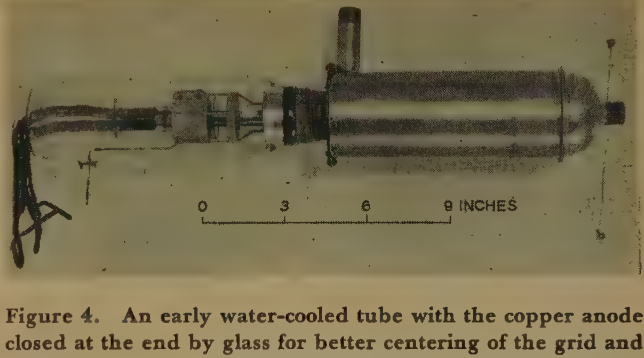


**Figure 4. An early water-cooled tube with the copper anode closed at the end by glass for better centering of the grid and filament structure**


**Figure 5. WL-473, a modern 100-megacycle air-cooled tube used in ultrahigh frequency dielectric heating and frequency modulation**

was the first practical case of a water-cooled copper-anode tube with a thoriated tungsten filament operated with 15–17 kv on the plate. Previously this type of filament had not been used with operating voltages above 4,000 or 5,000 volts.

*The Klystron.* In 1939, the Varian brothers working at Stanford University under the auspices of the Sperry Gyroscope Company announced the first practical tube based on a novel principal of velocity modulation of electrons in an electron beam, a principle which had been disclosed earlier by Heil in Germany. The Varians' tube was called the klystron and was capable of generating 10 to 15 watts at 10-centimeter wave lengths. The expectation was that the new tubes could help the development of automatic blind landing of airplanes and some other air navigation problems. However, during the subsequent years of war the 10-centimeter tube was manufactured in great quantities for use as a local oscillator in radar receivers. In the field of transmission the klystron yielded the leading role to the multicavity magnetron.

In the early work on the klystron, various important manufacturing processes were developed among which was the use of Kovar in ultrahigh-frequency tubes. Thus, when the multicavity magnetron and many other new tubes had to be constructed during the war, Kovar seals were used lavishly. As it is known, Kovar (a special nickel-iron alloy)[35,36] was developed originally for mercury vapor tube seals, but its use in ultrahigh-frequency tubes generally was considered taboo, because of its high resistivity and magnetic properties. Successful experience with klystrons reversed the verdict and, since then many ultrahigh-frequency tube designs have been benefited by the use of simple and mechanically strong glass-to-metal seals not requiring fine machining as did the original Housekeeper seals. But so strong was the force of habit that, when the simple Kovar seals were proposed originally and in 1941 actually replaced flimsy cooper seals in the multicavity magnetrons, it took some time before they were permitted officially. Now there is a general tendency all over the world to use Kovar in every newly designed tube.

## TUBES WITH FORCED-AIR COOLING

The introduction of water cooling on tube anodes was an enormous step forward in the art of building electron tubes for high power. Individual tubes with 100-, 200-, or 300-kw output are in use now. Maximum output from a "glass" or "radiation-cooled" tube hardly could exceed one or two kilowatts without making the tube too bulky and expensive. However, there is a steadily increasing number of instances in which a high output transmitter is necessary, but water cooling is not a desirable feature. For example, there may be danger of freezing the water, water may not be available in the necessary quantity, or water may be too contaminated and cause corrosion of tube anodes. In anticipation of such possibilities, experimentation with forced-air cooling was begun. Though at first the proposition was turned down by all prospective customers and design engineers, an urgent demand was made on tube designers in 1936 and 1937 to provide a scheme which would permit tube operation without fear of freezing the tube.

Theoretical study of various popular antifreezes ruled them out for this application. But theoretical study of and extensive experimenting with forced-air cooling gave encouraging results.[37] At the present time, for practically every water-cooled tube, ratings also are given for forced air cooling and specially designed multifin air coolers (incorrectly called radiators) are provided (Figure 5).

## OTHER MODERN TUBES

Tubes for a great variety of purposes have been manufactured for the government during the war by every tube manufacturer. The greatest number of manufactured tubes of all types were the multicavity magnetron, the 10-centimeter klystron, and the *530* tube. Among other contributions one may mention the important ultrahigh-frequency type *WL-473*, with 4-kw rated output, which was widely used for dielectric heating in industry, and suitable for ultrahigh-frequency frequency modulation, (Figure 5). The compact water-cooled tube type *WL-895* was employed in a great number in tin-reflowing installations. In addition the latter tube with air cooling is used successfully in radiobroadcast service.

Among the special developments which deserve mention is a gas-filled tube, containing a spark-gap and two vacuum tight windows, which enabled use of a single antenna for radar transmission and reception.[38]

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# Use of Welders for Thawing

According to a recent General Electric Company announcement, electric welding equipment has been used successfully to thaw frozen water pipes with no special equipment other than reliable pipe clamps for firm connections. Connections are made in the ordinary way with the work and electrode leads connected to the pipe on opposite ends of the frozen section so that the heat generated in the pipe wall will thaw the ice. The current to be used has been set at between 200 and 500 amperes, but the time required varies greatly. Tables I and II will help determine the various factors involved while Table III shows maximum outputs obtainable from equipment which normally would be used for pipe thawing purposes.

**Table I. Data for Use of Welders**

| Pipe Diameter (Inches) | Recommended Amperes | Approx. Minutes to Thaw | Recommended Cable Size | Resistance Per 100 Ft Cable |
|---|---|---|---|---|
| 1/4 | 75 | 15 | No. 6 | 0.0395 |
| 1/2 | 125 | 20 | No. 2 | 0.0156 |
| 3/4 | 200 | 20 | No. 0 | 0.00984 |
| 1 | 250 | 30 | No. 00 | 0.00780 |
| 1 1/2 | 300 | 30 | No. 000 | 0.00619 |
| 2 | 350 | 40 | No. 0000 | 0.00491 |
| 4 | 600 | 75 | 400,000 cir mils | 0.00270 |
| 6 | 800 | 120 | 600,000 cir mils | 0.00180 |

**Table II. Ohm Resistance Per 100 Feet, Standard Pipes**

| Pipe Diameter | Wrought Iron | Steel | Copper Tubing | Lead | Cast Iron, Class A |
|---|---|---|---|---|---|
| 1/2 | 0.026 | 0.0198 | 0.00824 | 0.0234 | |
| 3/4 | 0.0202 | 0.01485 | 0.00445 | 0.01371 | |
| 1 | 0.0138 | 0.0100 | 0.0034 | 0.00984 | |
| 1 1/2 | 0.00842 | 0.00618 | 0.00208 | 0.0064 | |
| 2 | 0.00625 | 0.0046 | 0.00133 | 0.0053 | |
| 4 | | | | | 0.0092 |
| 6 | | | | | 0.006 |

**Table III. Maximum Outputs**

| Equipment | 10 Volts | 20 Volts | 30 Volts | 40 Volts |
|---|---|---|---|---|
| 300-amp a-c welders | 500 amp | 450 amp | 400 amp | 375 amp |
| 500-amp a-c welders | 800 amp | 750 amp | 700 amp | 625 amp |
| 300-amp d-c welders | 650 amp | 600 amp | 500 amp | 400 amp |
| 400-amp d-c welders | 800 amp | 750 amp | 700 amp | 600 amp |
| 600-amp d-c welders | 1,200 amp | 1,000 amp | 900 amp | 700 amp |

# Aids for the Blind

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ASSOCIATE AIEE

**In the United States some 1,500 veterans of World War II and a total of approximately 240,000 persons are handicapped by loss of vision. Much has been done to aid these individuals, but the present occupational fields open to them are very limited. Development of suitable instruments for measuring and computing, guidance devices, and devices for reading printed material; and creation in the mind of industry a better attitude on capabilities of the blind are of major importance in their aid. Some progress has been made, but in order to overcome the limited application of Braille and the handicaps involved with guide dogs mechanical and electric equipment is being developed and refined.**

OF ALL THE wounded veterans perhaps the blinded must face the most serious problem. Those who have lost a leg or arm, who are now deaf, or who suffer in some other way have their eyes to help them get around. They can hold many jobs without necessity for special arrangements. But the blinded veteran must learn a new life—learn to manage everyday detail, learn to interpret human reactions through voice rather than face, learn to move about in a world geared for sight, either with the help of a dog, or learning to be always dependent on others. His place in the working world is shifted from one where many skills are utilized to a position where he is expected to do little else but make brooms, tune pianos, live in a home for the blind, and be pitied.

This was the situation only four years ago in the United States before blinded veterans began returning from World War II. The newspapers and magazines have contained much on what is being done. But, it is a recognizable fact that the public already has pushed thoughts about the war-handicapped into the background. The problem of the blind in a seeing world does not stem from World War II. There are perhaps 1,500 such cases from this war, but the number of blind in the country is approximately 240,000. It is the duty of the American public and industry and Government to do all in their power to help these veterans back to as normal a life as possible and to do it as gracefully and efficiently as practicable. In addition there is a large number of nonveterans who deserve consideration.

Something is being done, but not enough. It was said previously that the conditions outlined existed four years ago. Great strides have been taken since that time. The author, himself blind since the age of two, was graduated from a highly accredited college with good background in electrical engineering and physics. For three years he struggled to procure a position as an engineer in some industry. Finally, through the persistent efforts of O. E. Day (then the Philadelphia placement agent for the blind and now chief of the Pennsylvania Council for the Blind), the Radio Corporation of America in Camden, N. J., agreed to give the author a position as junior engineer in their quartz crystal development laboratory.

## INSTRUMENTS DEVELOPED

Problems were connected with the work that had to be solved, and the management was most co-operative in the matter of preparing special tools and arrangements. A special micrometer (Figure 1) was designed which permitted the dimensions of crystals to be determined as accurately as with a conventional micrometer used by seeing people. Scales in Braille were fitted to instruments so that frequency readings could be taken. A special volt-milliammeter (Figure 2) was developed to permit determination of current and voltage readings.

Through the prodigious labors of many people interested in the cause, many blind persons have been employed in industry during the past four years. It is not amiss to emphasize, however, that there are still some 40,000 eligible blind people waiting for a chance to prove

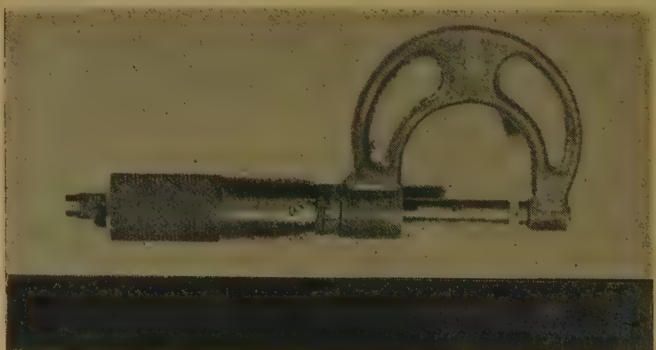

**Figure 1. Micrometer adapted for use by blind person with raised dot at zero on the barrel**

Essential substance of a paper presented before a meeting of the AIEE Philadelphia (Pa.) Section on March 11, 1946.

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**Figure 2. Volt-milliammeter with special pointer clamps and Braille scale**

**Figure 3. Calculator with housing cut away to permit tactual reading of Braille numbered indicator**

that they can compare favorably with their seeing co-workers if given opportunity and reasonable consideration. It has been demonstrated that these people are capable of even better performance than seeing persons in many instances.

The world has seen some development for overcoming the problems encountered by the blind over the period of the past 25 or 30 years which is an encouraging sign, but much more is possible. It is distressing to report that of the larger nations, the United States was behind up to the beginning of the war. Since then, however, considerable improvement is in evidence. The Army and Navy, two Government committees, and some private agencies, including the American Foundation for the Blind are giving attention to the development of instruments for the use of the visually handicapped. The problems of chief importance are providing suitable instruments for measuring and computing; a satisfactory method of enabling printed material to be read through the auditory or tactual senses; an instrument which will enable safe travel without encumbering the user unduly. Besides the micrometer, meter, and special scales mentioned before, the author has developed several other useful devices.

### CALCULATOR ADAPTED

During the period of employment with the Radio Corporation of America and later as a member of the physics and engineering staff at Haverford College, Haverford, Pa., the need for a calculator (Figure 3) became increasingly more evident. The ordinary slide rule cannot be used when relying on the sense of touch and calculating machines cannot be read. It was thought that the calculating machine might be adapted with Braille characters on the numbered dials. After an investigation of the various types of machines, only one or two models were found suitable. Either the dials were too small or they were too close together, with insufficient clearances to accomodate the dots of the Braille system. One of the suitable models was converted and the resulting machine has proved quite satisfactory from the standpoint of usefulness and cost. Celluloid strips carrying Braille numbers were fastened to the dials and the housing was cut away to permit access to the fingers. Through the use of this calculator the time of computing, as compared to hand methods, has been cut by a factor of ten or more and the strain on the mental processes has been reduced by an even larger factor. Negotiations are under way with the Monroe Calculating Machine Company for making these calculators available to the blind.

The simple meter referred to before (Figure 2) is used for making static measurements of voltages or currents. This meter is arranged to allow the pointer to swing freely over a Braille scale. When it is desired to take a reading, a button is pressed which clamps the pointer between two rubber cushions, thereby holding the needle firmly so that it will not be displaced when touched.

When necessary to tune for maxima or minima in voltage or current, the process of clamping and reading and then releasing, adjusting and reclamping is very slow and awkward. To obviate this limitation, an aural indicator has been developed. In this device a saturable reactor with its a-c coil as the inductance of an audio-oscillator is employed. The frequency of oscillation is adjusted through shunt capacity to about 200 cycles. When a current is passed through the d-c coil of the reactor, the inductance of the tuned circuit is lowered, thereby raising the frequency of the tone as heard from the loud-speaker. The instrument has a sensitivity of about 600 cycles per milliampere in the most sensitive

position. Maxima and minima adjustments can be performed easily and, once made, the absolute value of the resulting quantity can be measured with the simple meter. Also, when circuits are being adjusted, aural indications of current or voltage changes are available, thus making intelligent adjustments possible.

### FACILITIES IN MEASUREMENT

One Manufacturer's impedance bridge (Figure 4) fitted with celluloid Braille dials, extends the field of operation of the blind person. For making d-c measurements in any bridge circuit, earphones and an interrupter connected in series can be used to replace the usual galvanometer. To supplement this instrument, a circuit for rapidly determining small capacitance values has been constructed. The frequency of a radio-frequency oscillator is adjusted to give a definite audio beat in the output of a regenerative detector. The capacitance to be measured is connected across the tuned circuit of the oscillator and the tuning capacitor adjusted to restore the initial frequency. The amount of capacitance subtracted is the value of the unknown. A batch of 100 miscellaneous capacitors has been tested and sorted in less than 20 minutes by a relatively inexperienced blind person.

There is a very important aspect in the development of special instruments for the blind or the conversion of already existing apparatus which not always is considered carefully. This is the matter of making tools which are utterly useless to the operator's seeing coworkers. Plant management is not anxious to invest money in building or converting apparatus which will be useful to only one or two employees. It has been the author's goal always to create instruments which seeing people can use as readily as the more conventional ones. This means that Braille markings must not obscure printed indications, or that instruments must not depend solely on skills peculiar to the blind for their operation. The micrometer is a good example because the conventional markings are unimpaired. The meter, the calculator, and the other instruments, can also be used by anyone familiar with their operation.

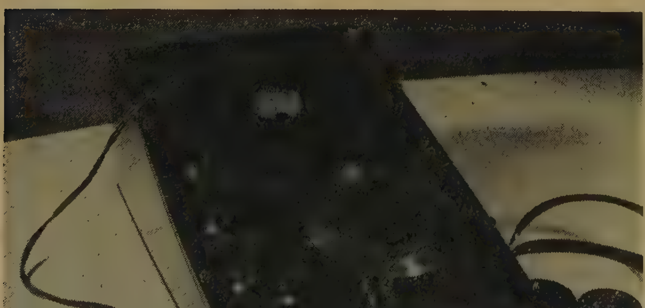

**Figure 4. An impedance bridge with Braille scale**

### RESEARCH FOR AIDS

The American Foundation for the Blind, with headquarters in New York, N. Y., was established for the purpose of bettering the lot of the individual so handicapped. This organization, which has been in existence for 25 years, recently has set up a technical research department, although previously much research was carried on under other departments. The talking book, which is a means of reading ordinary books through the agency of long-playing phonograph records, was introduced by the Foundation in 1934, since when it has been subsidized by the Federal Government through the Library of Congress.

The new research department, headed by Charles G. Ritter, hopes to co-operate with others in order to minimize duplication of effort. At present the problem of measuring devices is under consideration. One of the organizations with which the Foundation is co-operating is the federal Committee on Sensory Devices, headed by Doctor G. W. Corner. Doctor C. M. Witcher of this committee, who has been blind since very early childhood and who received his doctor's degree from Columbia University, has developed an improved micrometer which will require less training and skill to operate than the model mentioned before. He also has developed a vernier caliper which a blind person can read accurately to 1/64 of an inch. Other adaptations currently under investigation are apparatus for physiotherapy, typewriters for transcribing Braille music, pressure cookers, soldering irons, and woodworking tools.

### READING MACHINES

The problem of reading printed material always has been a serious obstacle to those who cannot see. Several machines have been built to overcome this handicap, but so far they all have been either too bulky and expensive or they required such great skill to operate that only a very few would have the patience and ability to master them. A device known as the "Visigraph" produces enlarged raised duplicates of the printed letters which can be scanned with the fingers. One would think this to be quite practical because Braille is a similar tactual process. However, the printed letters are not identified easily by the fingers as demonstrated by the fact that the early printing systems for the blind were based on this principle and when Louis Braille, born in France in 1809, invented the dot system now universally used, the raised printed letter was dropped.

Another reading machine, the "Optophone," has been developed by a British firm. This device depends on the user interpreting code signals of varying frequency and intensity. The character of the tone depends

on the density of the ink on the letter being scanned by five spots of light. This machine was developed for a particular person who had far greater than average intelligence. He learned to use it, but the average blind person probably never would attain sufficient speed to make the instrument practical.

Doctor V. K. Zworykin, of the research laboratories of the Radio Corporation of America, has brought to the attention of the Corner Committee a device[1] which he has designed. It consists of a pen-shaped scanner or stylus carrying a photoelectric cell. The tip of the stylus is run along the illuminated printed material and the different intensities of light picked up by the cell are reproduced as aural tones. This has the same limitations as the Optophone. However, there is some possibility that it can be used for reading instruments such as meters and certain gauges. This would be of great assistance, because any meter or gauge could be read thereby eliminating the need for instruments of special design.

Another idea for a reading machine conceived by A. Roberts Sharples, a high-ranking electrical engineer in the Philadelphia Navy Yard, is in the patent stage. If sufficient funds can be raised to sponsor the construction of a model of this machine, it can be decided whether the idea is practical. The principle is not involved and the operator needs no special skill. Material to be read is placed in a frame which lines it up for scanning by a beam of light. The reflected light is focused on a variable-speed rotating opaque disk carrying transparent replicas of the printed letters. Behind this disk is a photoelectric cell. When the letter on the disk corresponds to the dark portion of the reflected light, the photoelectric cell receives no light and triggers a circuit which involves a film or steel wire on which are recorded the spoken versions of the letters. The film or wire rotates in synchronism with the disk. When the photoelectric cell triggers the circuit, the letters are heard by the operator through earphones or loudspeaker at a speed which he can follow. It is thought that a speed of 25 to 30 words per minute could be attained by a person of normal intelligence. This reading machine would not satisfy all reading needs because the variations in print and the large number of characters involved, particularly in mathematics, would require too large a selection of rotating disks, but it would appear to be one of the best solutions to the problem.

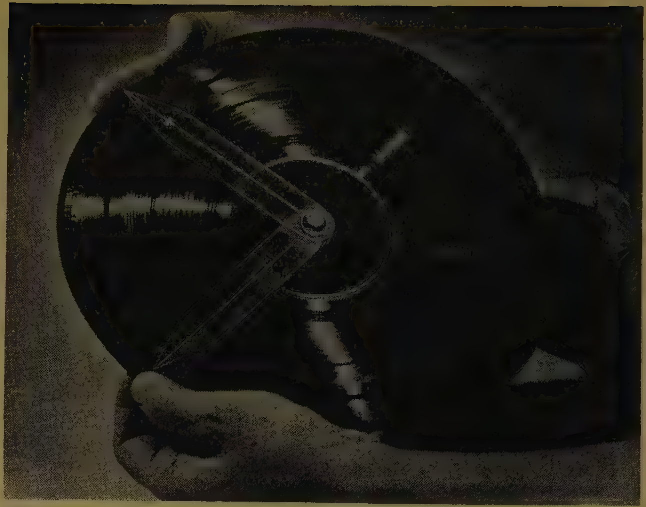

Photo courtesy *Popular Science Monthly*

**Figure 5. Circular slide rule with Braille markings on reverse side for quick location of raised graduations on front**

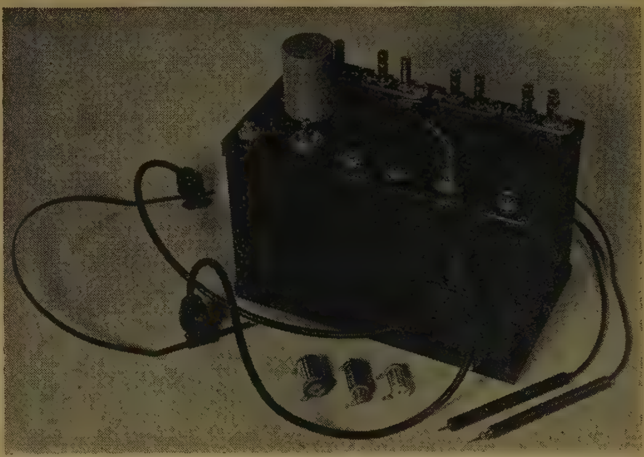

**Figure 6. Null-type Wheatstone bridge analyzer with Braille scale[3]**

## GUIDANCE DEVICES

The problem of finding a suitable guidance device is being considered seriously by the Army, Navy, and the Haskin's Laboratories. Many attempts have been made in the past with emphasis on special canes. All such attempts have been unsatisfactory because they did not give sufficient warning of obstacles, steps, or holes. They could not be used inconspicuously or gracefully, particularly for informing the user of overhead obstacles.

The guide dog is the best solution thus far. There are many who feel that the care and consideration the dog requires is a serious inconvenience. When compared with mechanical or electric devices, the dog has one outstanding advantage, the limited ability to think and reason. No matter what sort of guidance device the blind person has, he must know where he is going, and must either be familiar with the territory or must be able to follow directions when in strange surroundings. The dog will follow his directions intelligently, but the mechanical instrument simply will warn of changes in terrain.

A group of men under the jurisdiction of the Army is working on a device[2] which employs a beam of light as the medium for conveying the desired intelligence. The operator scans the terrain in front of him with this beam, and the reflected light is focused on a photoelectric cell the circuit for which converts the light into an aural stimulus. Variations in distance are indicated by different dot spacing and dot length.

The Haskin's Laboratories are working on a device which employs supersonic waves as the detecting medium. The apparatus consists of a transmitter which sends out frequency-modulated sound waves of about 30 kc and a receiver to pick up the reflected energy. The transmitted and reflected waves are combined in a detector the output of which is applied to an earphone. Frequency of the reflected waves is different from that of the waves being transmitted at that instant so that an audible beat is heard in the phone. The pitch of this beat which depends on the distance to the reflecting object will be higher for distant objects than for objects which are near.

The bat, who employs a system similar to radar for his guidance device, sends out short duration pulses having a frequency of about 50 kilocycles. The intensity, time lapse, or combination of both quantities of the returning signal gives it the range, while aural focusing gives it the direction. Aural focusing is used by everyone for ascertaining the direction from which sounds come, but the unaided human ear is not capable of employing supersonic waves required for good reflection from small objects. The direction from which a sound emanates is determined by learning to interpret the difference in intensity of the wave as heard by the ears, one being closer to the source than the other, and by the difference in phase of the wave as heard by the two ears. Sources of high-frequency sounds, those between 1,000 and 10,000 cycles, are located most accurately because the shadow cast by the head causes the far ear to hear the sound less strongly. The sound of a person's footsteps reflecting from objects can be heard by most blind people which enables them to avoid obstacles quite well under favorable circumstances. However, holes or down-leading stairs do not reflect such sounds and thus constitute major hazards. Also, noises from traffic or machinery will mask reflections. The guidance devices mentioned will overcome these difficulties, if and when they are perfected.

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# Temperature Records as an Aid in Depreciation Study


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RECENT DEVELOPMENTS in the knowledge of the factors influencing the rate of deterioration of insulating materials have extended the power of engineering statistics for determining the amount of accrued physical depreciation in electric equipment. Procedures based on these developments and adapted to the particular case under investigation should be of considerable help in valuation work. A short time ago the author had occasion to determine the depreciation of the electrical components of a utility property of substantial size containing a number of generators and transformers of varying age. Recognizing the importance of heat in the deterioration of insulating materials, an investigation was made of the company's records with respect to the age and temperature history of the windings of the individual items of equipment, to which this principle was applied with gratifying results.

There is no reason why the method cannot be used for any other equipment involving substantial proportions of insulating materials. The results apply, of course, only to that portion of a particular piece of equipment which depends upon the adequacy of the insulation, and are reflected in the value of the whole to the extent that failure of the insulation will affect the value of the whole. For instance, generators and transformers ordinarily can be rewound. If the value of the armature and field windings of a generator, for instance, represents 30 per cent of the undepreciated value of the machine, the procedure would be applied to that portion, less its scrap value, and the remainder of the generator would be treated in another way. Inasmuch as the rate of deterioration of the other parts


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of the machine ordinarily not offset by maintenance is relatively slow, the deterioration of the windings usually will represent the bulk of the total physical depreciation of the machine.

The value of this approach to the problem resides in the fact that it utilizes a combination of real engineering data and actual records, in contrast to the purely actuarial approach. The latter method has been tried by a number of investigators, but with results of doubtful significance and questionable legal force when used for individual items of large value. Mere contemplation of the kaleidoscopic development of the electrical industry reveals why this should be so. Most replacements of major items of an electrical plant have been occasioned by obsolescence and inadequacy. While such equipment often is purchased by a subsequent user, resale value is not a reliable gauge of intrinsic worth. There has not been a sufficient background of experience, independent of such obscuring complications, upon which to build a sound actuarial analysis. For these reasons valuation still remains primarily an engineering problem, and it is with this in mind that the following discussion of depreciation, as measured by deterioration, is offered.

**A new method of determining depreciation of electric equipment consists of co-ordinating test and experience data which have been published from time to time and applying the results to an engineering analysis of the temperature history of the equipment as developed from its operating records. The author cites one instance where the method was used with gratifying results in recent valuation work and so believes that the information may be applied profitably to similar or related work.**

## TEMPERATURE PERFORMANCE

Temperature long has been recognized as the predominant factor influencing the rate of deterioration of the common nonceramic insulating materials. There are other factors, such as moisture conditions, chemical nature of the surrounding medium, physical wear and tear, mechanical shock, and the like, but with sound design and application their effects usually are reduced to a minor role. Temperature thus remains the prime factor and, as such, is a function of the service to which the equipment is put.

This last statement is of paramount significance. It indicates that temperature bears a close relation to service requirements, and by extension of this idea temperature history should be related closely to service life. It has become customary to apply this principle in the operation of equipment, by basing the service demands upon the temperature which the equipment attains in operation. This is treated commonly as an economic problem. Experience has shown that if the equipment is operated at unusually high temperatures its life will be dissipated faster than a return can be realized by its use, while if the temperatures are exceptionally low the investment required will be too large to produce a favorable return. The advances of the past several years in our knowledge of the relation between temperature and deterioration of insulation now permit a fairly close determination of the economical loading of equipment. The same principle can be applied, in reverse, to determine the extent to which deterioration has accumulated by reason of the temperature history of the equipment.

The widespread use of temperature as a guide to operation should provide sufficient support for its use in determining depreciation. It is, first and foremost, the basis on which equipment is rated for service, and is the main criterion by which the manufacturers guarantee the life of their product. Applied to loading, as described in the foregoing, it usually is employed to the practical disregard of name plate ratings. This is done with the approval of the manufacturers, their guarantees remaining valid. Generators and transformers often are bought with multiple ratings based on temperature performance. There have been numerous articles published on the cyclic loading of generators, transformers, and cables, containing data, charts, and other means for computing the optimum loads for various conditions. This practice received further impetus during the war at the urging of the Federal Government to obtain added output from existing plant equipment. If there can be any economics applied to armed conflict it may be said that we were willing to dissipate the life of our equipment so much faster in order to win the war so much sooner, but not so fast as to wear it out before it had served its proper purpose in the war effort.

## EFFECTS OF TEMPERATURE

Present knowledge of the subject of insulation deterioration is the result of a gradually increasing fund of data reaching back to before the turn of the century. Early findings were based on experience and field observations as the industry began to grow. Present findings have behind them the added years of a mature industry, coupled with laboratory tests to determine the effects of various factors on the insulating qualities. The organic types of materials, class *A*, having been used earlier and more widely, have been investigated more thoroughly, but in recent years reliable data on the inorganic types, class *B*, have been accumulated to a gratifying degree.

The laboratory investigations have taken the direction of correlating the life of insulation with its mechanical

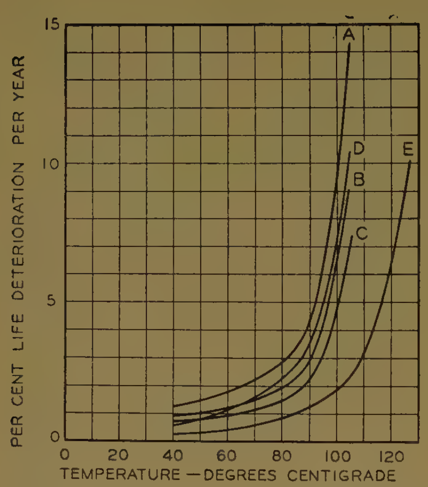



**Figure 1. Curves showing annual percentage dissipation of life of insulating material**

strength. Other desirable qualities seem to follow the same trend so that mechanical strength is a reliable indicator, and, moreover, appears to be the most important quality. While a certain amount of valuable work was done on this subject before 1930, one of the best papers[1] was published in April of that year. This paper establishes a sound basis for the relative deterioration of class *A* insulation immersed in oil for various temperatures, and its rate with time. Other papers[2,3,4] have furnished equivalent information for classes *A* and *B* in air and also for class *A* immersed in oil under atmospheres of dry air and nitrogen. These cover the range of ordinary rotating machinery and also the various types of transformers, the old open type, the conservator type, and the present inert gas type.

While refining the results of previous work, recent investigations have substantiated the earlier findings with respect to the effects of both intensity and duration of heat. The relationship is exponential, the rate of deterioration increasing as some power of the temperature greater than the first power, as indicated by the curves in Figure 1. Experience bears this out, and also confirms the judgment of these investigators in rating the efficacy of the insulation in terms of its mechanical strength rather than its electrical qualities. Breakdown does not occur ordinarily because the insulation has lost its ability to withstand a particular voltage, but because a physical flaw has developed to sufficient degree in some local region. Even then the insulation may serve for some time if it is not disturbed. In the last analysis it is often some disturbance which signalizes the eventual breakdown. For this reason the study of the life expectancy of insulating materials cannot be reduced to an exact science. The insulation does not simply give up the ghost and quit after a certain stage has been reached. While the condition itself can be determined with a reasonable degree of accuracy, all that can be said is that when this condition has been reached a small increment of stress may cause extensive breakdown. Any of the momentary stresses incident to normal use may cause this, such as a current or voltage surge, or the slight disturbance occurring during inspection or some necessary minor repair. Sometimes when a piece of old equipment is moved to a new location it will require extensive repairs even though it was operating satisfactorily before being taken out of service. The jarring incident to relocating it has precipitated the imminent disintegration of the insulation.

## DATA REQUIRED

Most companies have fairly complete records of the temperature performance of their major items of equipment. Even when such records are lacking, a suitable temperature history can be developed with the help of test data and the load cycle. The particular method of analysis will depend upon the nature of the information available and the degree of detail desired. Refinement beyond the degree of accuracy of the temperature deterioration data is not warranted, but, as indicated, the amount of information now available on this subject is sufficient to justify a fairly comprehensive study of the temperature history.

In order to make an analysis of this kind a set of curves such as shown in Figure 1, or similar information, is required. There are five curves shown, each giving the annual percentage dissipation of the life of a particular kind of insulating material at various temperatures under different conditions. Curve *A* is for class *A* insulation immersed in oil which is exposed to the atmosphere. This would apply to transformers of the old "open" type, of which there are many still in use. Curve *B* is for class *A* insulation immersed in oil which is exposed to air that is protected against the absorption of moisture. This would correspond to transformers of the conservator type, of which there are also many in service. Curve *C* is for class *A* insulation immersed in oil which is under an atmosphere of dry nitrogen. This would apply to the modern inert gas type of transformer. Curves *D* and *E* are, respectively, for class *A* and class *B* insulation exposed to air. This would apply to rotating electric machinery with the particular class of insulation designated.

As implied by the foregoing comments, application of these curves must be tempered with judgment. It is not possible to predict from them the day or even the year when the insulation finally will break down. The curves are derived mainly from investigations by a number of different individuals, as correlated by the author's experience. They are based on the tensile strength of the material after various lengths of exposure to conditions corresponding to those stated. It can be assumed that other useful properties will be dissipated in a reasonably similar manner. The degree to which actual operating conditions approximate those of the test must be considered carefully. It may be feasible

also to make some allowance for the effects of other factors, such as those mentioned earlier. For instance, it might be advisable to differentiate between high speed and low speed rotating machinery, such as steam turbine and hydraulic turbine generators, in order to allow for differences in mechanical stress. The nature and accuracy of the records on which the temperature history is based also should be weighed carefully.

Notwithstanding the several variants which enter the problem, a sufficiently definite evaluation of the accrued deterioration can be made in most cases. The answer obtained, while subject to judgment, has behind it real engineering facts and the actual history of the individual machine. Such an answer must be given much more weight than any which is derived from general averages or simple fiat, no matter how authoritative.

## DESCRIPTION OF A TYPICAL APPLICATION

In order to illustrate one method of developing the temperature history and the manner of using the curves, the following short description is given of the procedure used in the afore-mentioned instance. The generating plant studied consists of ten vertical water wheel generators, two steam turbogenerators, and 17 3-phase step-up transformers. The water wheel generators are all of the open air-cooled type. The steam-driven units are of the closed recirculated air type with water cooling. Some of the transformers are water-cooled and some self-cooled. Some are of the old open type, some of the conservator type, and some of the inert gas type. Considering all generators and transformers, the ages varied from about 36 years to five years. Some of the earlier units have been rewound completely, however, so that the oldest winding to be considered was 34 years old. From what has been said it will be evident that the method of analysis proposed applies only to the windings. Therefore it is the age of the windings which must be used in the computations and not the age of the unit.

A study of plant operation and load requirements, and the available plant records revealed that it was possible to use a "typical day" method for developing the temperature history of each unit. Loading of the hydraulic generators is based primarily on stream flow and demand, while the steam generators operate practically as base load units. Interconnections with other plants permit stabilizing the demand to a reasonable correspondence with stream flow. This greatly simplified the selection of the typical days. For stream flow at or above the maximum capacity of the hydraulic plant, all available hydraulic generators usually can be operated at full output, limited either by the water wheel capacity for the net head or by generator temperature. For stream flows below maximum plant capacity the units are operated at best plant efficiency, the order in which the units are put on or taken off the line being fairly regular. The two steam generators are operated mostly at full load, this being limited either by the capacity of the steam end when the river water used for cooling is cold, or by generator temperature when the river water is warm. As practically all the plant load goes out through the transformers, their loadings more or less follow the generator loads.

Company records include extensive stream-flow data and daily log sheets giving hourly load and temperatures of the generators and transformers. Most of the temperature detectors are of the embedded resistance type, some giving local temperatures and some being adjusted to give hot-spot readings. All temperature recordings used were adjusted to make some allowance for hot-spot conditions, but scaled in accordance with external temperature differential on the assumption that the internal temperature gradient of the unit follows the external gradient to a certain extent. The stream-flow data include average flow duration curves, by months, for 25 recent consecutive years. These were combined into 3-month groups, corresponding to the four seasons of the year. Each of these four resultant curves then was divided into five stream-flow ranges, one being for all flows above maximum plant capacity, and the other four covering in equal steps all flows below that value. Adjustment for high tailwater during extremely high flow was not deemed necessary as the point at which this begins to affect plant output appreciably is well above maximum plant output.

It was now possible to make an intelligent selection of typical days for the hydraulic generators. These were chosen, insofar as possible, from near the middle of each season and from near the middle of the four stream-flow ranges below maximum plant output, those for the high range being selected for flows substantially above that point. A minimum of 20 typical days thus is seen to be required, one for each of the four seasons and one for each of the five stream-flow ranges. Any multiple of that number could be used to obtain a closer average. A more detailed breakdown using a larger number of monthly groups and a greater number of stream-flow ranges also could be used, but did not seem to be indicated in the case studied. So-called "normal" days were used for the typical days. That is, Saturdays, Sundays, and holidays were not used and Mondays were avoided. Also eliminated from use as typical days were any presenting extraordinary circumstances, such as floods, unusual plant shutdowns, and the like. Records for a particular unit were based on days during which that unit was wholly available for service, whether run or not. With these limitations the typical days were taken more or less at random from the past several years in order to average up seasonal conditions.

The same days were used in connection with the transformer study, or an equivalent substitute if any day selected did not happen to be "normal" for the unit in question.

The nature of the steam load would indicate fewer

typical days to be required for the study of the turbogenerators. A selection by seasons is required because the range in river water temperature is from a fraction of a degree centigrade to nearly 30 degrees centigrade. However, in order to catch any effect that stream flow might have on steam operation, and also to give a broader base to the average, the same number of days was used as in the hydraulic study. In fact, the same days were used whenever they were "normal" for the steam units.

From the log sheets for each of these typical days a tabulation was made of the length of time each unit was operated within a given range of temperature. Nonrunning time of sufficient duration to allow fairly complete cooling of the unit was taken at ambient temperature as log sheet readings were not taken during these periods. An allowance had to be made for the cooling-off time. The size of the temperature ranges taken would depend upon the degree of detail desired or indicated possible by the accuracy of the other elements of the data. Single degree steps were not deemed necessary in this case. The top degree or two comprised one step, with 5-degree steps below that until near ambient temperature, when wider ranges were taken. The lower ranges, of course, have less influence on the deterioration, and the accuracy required is relatively less than that for the higher temperatures.

The number of hours in each temperature range for all typical days was totaled up for each unit. This value, when divided by the number of typical days used and multiplied by the number of days in a year, gives the number of hours per average year the unit operates in each temperature range. An adjustment was made in these range totals for some units to allow for outage time for regular inspection and servicing, and also irregular outages. The adjusted annual hours for each temperature range, when divided by 8,760, the number of hours in a year, gives the fraction of a year in each temperature range. The annual rate of deterioration for each range, as read from the appropriate curve for the insulation of the particular unit, then is multiplied by this fraction of a year so determined for the particular temperature range. This gives the per cent deterioration due to the established length of operation in each temperature range. The sum of all these percentages for all temperature ranges used gives the total annual deterioration (for an average year). This value, when multiplied by the age of the winding in years, gives the total percentage deterioration which has accumulated throughout the accrued age of the winding. This is the value sought.

## USE OF RESULTS

The accuracy of the percentage deterioration thus determined will depend upon the accuracy of the basic deterioration rates used, the extent to which the typical days used represent past operating conditions, and the degree of detail used in the temperature analysis. It is believed that the curves presented herewith will approximate average rates for the deterioration. The final result should give a reasonably good indication of the condition of the windings. Inasmuch as the method is approximate and, furthermore, inasmuch as a unit of advanced age may continue to give service if not subjected to unduly severe service, it easily may happen that the result determined by this analysis will indicate a value greater than 100 per cent for very old units or units which have operated consistently at high temperatures. In such cases much credit is to be given to the builders and operators of the unit, and it should be recognized that the unit now has reached that stage when it has given all the service it was intended to give, and may be expected to yield its place to a younger and more vigorous unit at any time.

The percentage of deterioration determined by this method must be recognized as applying strictly to the windings, as has been pointed out in the foregoing. Just what is done with it will depend upon the problem at hand. Its minimum significance is that it indicates the extent of the accumulated dissipation of that portion of the value of the entire unit represented by the value of the windings. To it may be added other percentages representing irreplaceable deterioration of other parts of the unit. Adjustments also may be made for other factors in depreciation, such as deferred maintenance, inadequacy, and obsolescence, and any further adjustments for known singularities of the individual unit, possible salvage, or special conditions. Finally, the actual value assigned to the depreciation of the unit will depend upon the fiscal policies to be followed, such as the use of the sinking fund method, or other procedure for accumulating the depreciation reserve.

It may be stated in conclusion that the method outlined yielded results in practical application which corresponded closely with opinions independently arrived at by the usual methods by competent observers. These included the plant operators who knew the units intimately from daily experience over long years of service, and experienced outside consultants who investigated the operating history of the units, studied detailed inspection reports, and made personal inspections. It is believed, therefore, that the method proposed offers a means of determining, by a real engineering analysis, the accrued extent of the largest single element in the physical depreciation of electric equipment.

## REFERENCES


1. Loading Transformers by Temperature, **V. M. Montsinger.** AIEE *Transactions*, volume 49, April 1930, pages 776–90.

2. Factors Affecting the Mechanical Deterioration of Cellulose Insulation, **F. M. Clark.** AIEE *Transactions*, volume 61, 1942, October section, 742–9.

3. Emergency Overloads for Oil-Insulated Transformers, **F. J. Vogel, T. K. Sloat.** AIEE *Transactions*, volume 61, 1942, September section, pages 669–73.

4. Synthetic Insulation and the 10-Degree Rule, **G. L. Moses.** *Westinghouse Engineer*, July 1945, pages 106–07.

# INSTITUTE ACTIVITIES

## Middle Eastern District Holds Conference for Students

A conference of students and counselors held by AIEE Middle Eastern District, October 26, 1946, at Pennsylvania State College, State College, Pa., was attended by 23 students, and 10 faculty members representing 8 different educational institutions.

Speaking on "What Industry Expects of the Electrical Graduate," Past President C. A. Powel (F '41) attributed the growth of engineering schools from the half dozen of 80 years ago to the 133 accredited last year by the Engineers' Council for Professional Development, to the increasing demand by business organizations for men with engineering training.

In discussing the interaction of industry and education he mentioned that, as engineering enrollments grew, larger numbers of engineers were drawn into less technical work, such as manufacturing and sales. This in turn caused the educational institutions to include more subjects of a nontechnical nature. He declared that the nature of instruction changes with the demands of industry, and as a result more courses now require English, history, and economics than in the early days of engineering.

Mr. Powel stated in analyzing engineering opportunities that it is much easier to change from a technical engineering position to commercial work than to accomplish the reverse. The fact that technical work must be followed continuously to keep abreast of developments accounts for this. The Westinghouse corporation, Mr. Powel revealed, employs about 5,000 engineers, between 80 and 90 per cent of whom entered the corporation immediately after graduation. Of the corporation's 2,500 supervisory employees, between 700 and 800 have had engineering training.

In conclusion Mr. Powel gave the opinion that it is an engineer's duty to affiliate himself with the AIEE because it represents the continuous tie between generations of engineers.

Doctor J. F. Calvert (F '45) chairman of the AIEE committee on Student Branches, discussed some of the achievements, limitations, and some of the possible shortcomings of the AIEE. He stated that, though the AIEE has contributed immeasurably to the achievement of the art and science of electrical engineering, nevertheless it seems to have failed at times as evidenced by the organization of such societies as the Institute of Radio Engineers and the Illuminating Engineering Society. Another service rendered to the engineering profession by the AIEE was the establishment and maintenance of technical standards for equipment and technical procedures, he said.

Doctor Calvert asked why it is that the building and owning of a home today takes about as much on a percentage basis of real wealth as it ever did in the past. He suggested that engineers might get together and work on building codes which would encourage the use of power tools or the development of quantity production methods.

Regarding the Student Branches, he said that the students should be trained properly and guided, so that they will be able to carry on the technical developments, high standards, and procedures of the AIEE. He stated that he believed the Student Branch organization should be blended with other major engineering societies into one group, so that the students will have a general picture of the engineering field.

He said that the committee on Student Branches favored the plan of having one Student Branch at an institution through which students would pay dues to the national society in their field. He expressed approval of a plan by which a student in good standing could join the national society at graduation without payment of an additional fee.

A. A. Johnson (M '44) District secretary, talked on AIEE District affairs, and J. F. Fairman (F '35) chairman of the AIEE committee on planning and co-ordination, discussed the four plans (*EE, Apr '46, pp 169–73*) for reorganizing all engineers into one society and distributed questionnaires to ascertain opinion on the subject.

Professor L. A. Doggett (F '36) gave a very interesting talk on the subject "What Happens to the Occupants Thereof." In this talk, Professor Doggett outlined the manner in which he keeps a record of the engineering graduates of Pennsylvania State College and pointed out the achievements of many of the graduates. As a matter of general interest, he indicated that of a total of 2,389 graduates to 1941, a total of 1,065 were employed by five of the larger types of organizations.

| | |
|---|---|
| Power companies | 323 |
| Communication companies | 285 |
| General Electric Company | 208 |
| Westinghouse Electric Corporation | 154 |
| Pennsylvania Railroad | 95 |

Dean H. P. Hammond of Pennsylvania State College spoke on "The Engineering Societies of America," and Professor P. X. Rice (M '43) of Pennsylvania State College, who is District chairman of student activities, gave an extemporaneous talk on the topic, "Here Are Seats of Honor and Responsibility."

### Committee Appointed for Summer Meeting

Appointment of the 1947 summer meeting committee by AIEE President J. E. Housley (F '43) has been announced. The meeting will be held this year in Montreal, Quebec, Canada, and will be two weeks earlier than usual, June 9–13. Members of the committee, all of Montreal, are:

Doctor De Gaspe Beaubien (M '21), *chairman*, H. W. Haberl (M '45), D. M. Farnham (M '42), F. L. Lawton (M '36), W. R. Simmons (M '43), M. C. Thurling (M '43), and Dan Anderson (M '45), and J. A. Beauchemin and J. M. Crawford (M '45) as representatives of the Engineering Institute of Canada.

### Future AIEE Meetings

**Winter Meeting**
New York, N. Y., January 27–31, 1947

**North Eastern District Meeting**
Worcester, Mass., April 23–25, 1947

**Summer Meeting**
Montreal, Quebec, Canada, June 9–13, 1947

**Middle Eastern District Meeting**
Dayton, Ohio, September 23–25, 1947

**Midwest Meeting**
Chicago, Ill., November 3–7, 1947

### AIEE Transactions Sought for War-Damaged Libraries

Inquiries are received occasionally from members who find themselves in possession of AIEE *Transactions* volumes which are surplus to their current needs. All members are reminded hereby that AIEE *Transactions* volumes, singly, in groups, or in complete sets, would constitute an especially acceptable and useful contribution toward the re-establishment of war-damaged libraries overseas. Members willing to part with their *Transactions* volumes for this purpose, should correspond directly with the Secretary, Committee on International Relations, Engineering Societies Building, 29 West 39th Street, New York 18, N. Y. The committee will furnish decorative bookplates which may be inscribed and mounted in the volumes by the donor; also, will provide complete shipping instructions.

The Committee on International Relations is the operating element of the Engi-

neers Joint Council which is representing five national engineering societies, in collaboration with the American Book Center for War Devasted Libraries, Inc., in efforts to help restore engineering and other libraries overseas. The American Book Center, which has its headquarters in the Library of Congress, Washington, D. C., is functioning as the central handling point for volumes contributed through the engineering societies, and receives, assorts, assigns, packs, and ships the contributed books. For additional information see *Electrical Engineering*, July 1946, pages 360–1.

## AIEE Proceedings Order Form Appears

The first order form for AIEE *Proceedings* appears on pages 33A–34A in the advertising section of this issue. As previously announced (*EE, Dec '46, pp 576–8; Jan '47, pp 82–3*) *Proceedings* is a new series of publications designed for the technical specialist and consisting of individual sections in pamphlet form, each containing full formal text of a technical paper with its related discussion, if any. *Proceedings* sections are available to Associates, Members, and Fellows, in accordance with the instructions given on the order form.

Because of the inclusion of discussion in *Proceedings* sections, their distribution necessarily will be delayed for some weeks following the presentation of the paper in order to allow for submission, approval, and printing of the discussion.

## Eighth Report Submitted on AIEE Aeronautical Standards

The eighth progress report covering the status of projects of the air transportation committee as of October 18, 1946, recently was submitted to the AIEE Standards committee. Developments in the work of standardization since the seventh progress report (*EE, Aug-Sept '46, pp 407-08*) dated June 27, 1946 are given in the reports of the subcommittees.

*Aircraft Electric Systems* [*Subcommittee chairman, R. H. Kaufmann* (*M '41*)]. The status of the work of this subcommittee was reviewed thoroughly at the September 23–24 meeting of the air transportation committee. An intensive drive is under way at present to procure sufficient material in finished form to issue a preliminary report covering some of the more important sections of the guide report. It is hoped that this preliminary material will be available for presentation in conference paper form at the conference on "Factors Affecting Safe Operation of Electric Apparatus in Aircraft" to be held during the AIEE winter meeting in January 1947.

*Aircraft Electric Rotating Machinery* [*Subcommittee chairman, M. L. Schmidt* (*M '43*)]. It is expected that the Standards committee will act during its October 22d meeting upon the recommendation of the air transportation committee that the "Test Code for Aircraft D-C Machines" mentioned in the last progress report be issued for one year's trial use.

This subcommittee now is undertaking a report on the principles for rating aircraft generators in line with a new assignment made September 23.

*Aircraft Electric Control, Protective Devices, and Cable* (*Subcommittee chairman, J. C. Cunningham, Jr.*). This subcommittee has been formed by combining the assignments of some of the personnel of the former subcommittees for aircraft wire and cable and for aircraft electric control and protective devices. At the present time, this subcommittee has reviewed the report of the aircraft wire and cable subcommittee and has edited it in suitable form for publication and for circulation to the Society of Automotive Engineers *A-2* committee. Much of the same material is also to be published as a "Test Code for Determining Short-Time Ratings of Aircraft Cable," and it is proposed to include with the test code an application guide report listing permissible short-time ratings of standard aircraft cable *AN-J-C-48a*.

This subcommittee also is engaged actively in work on recovery voltages for the use of the aircraft electric systems subcommittee and for future use in connection with test codes for protective devices.

This subcommittee also is assigned the task of developing a test code for aircraft circuit breakers.

*Basic Principles of Altitude Rating* [*Subcommittee chairman, W. E. Pakala* (*M '45*)]. This subcommittee is attempting to develop standards covering the basic principles for rating electric apparatus to be used at altitudes up to a maximum of 50,000 feet. It is recognized that test results and general performance of electric apparatus are influenced by conditions such as temperature, pressure, altitude, density, and humidity of the surrounding air. Existing standards for rating aircraft electric apparatus do not cover the range of conditions encountered in aircraft operation. Organization of this subcommittee is being completed at present, and the subcommittee is reviewing previous work on this problem. The work of this subcommittee will be co-ordinated closely with the work of the subcommittee on aircraft electric machinery and with the work being carried on by AIEE Standards co-ordinating committee number 1.

*Joint Committee on Carbon Brushes* [*Subcommittee chairman, V. P. Hessler* (*F '43*)]. This is a joint subcommittee of the electric machinery committee and the air transportation committee.

*Aircraft D-C Apparatus Voltage Rating* (*AIEE 700*). Revision of this Standard has been referred to the Standards committee under date of August 16, together with the results of balloting regarding this draft. Substantial agreement has been obtained on all matters except the nominal system voltage designation. Industry groups are about equally divided as to whether systems should be designated 12 and 24 volts, or 14 and 28 volts, respectively. The Standards committee has been asked to determine whether the new draft should be issued as a Standard or issued for another year of trial use.

*Conference on Factors Affecting Safe Operation of Electric Apparatus and Aircraft—Annual Winter Meeting.* At the September 23–24 meeting, the air transportation committee voted to hold an all-day conference during the AIEE winter meeting to explore thoroughly all factors affecting safe operation of electric apparatus in aircraft. This action was contingent upon approval of the proposed conference by the Civil Aeronautics Administration and the air line operators. Tentative approval of CAA participation was obtained October 8, and a formal request to the administrator was made October 15. It is expected that at this conference the views of CAA, the Army Air Forces, Navy Bureau of Aeronautics, airframe manufacturers, air line operators, and accessory manufacturers will be discussed.

*SAE Committee A-2—Aircraft Electric Equipment.* A very successful joint meeting of the SAE *A-2* and AIEE air transportation committees was held September 24, and it is expected that closely co-ordinated activities of these committees will result in added effectiveness of the standardization activities of both groups.

## 1946 December Supplement to Be Available Soon

Papers and discussions approved by the technical program committee for presentation at AIEE meetings in 1946 and which were not published in the monthly *Transactions* section of *Electrical Engineering* or in the June supplement will appear in the December 1946 "Supplement to Electrical Engineering—Transactions Section." The December supplement will contain 30 technical papers, discussions of those papers, and discussions of the papers already published in the July–December monthly sections. Issuance of the December supplement will complete publication of papers presented before the 1946 North Eastern District meeting in Buffalo, N. Y., April 24–25; the 1946 summer meeting, Detroit, Mich., June 24–28; the 1946 Pacific Coast meeting, Seattle, Wash., August 26–30; and the 1946 Great Lakes District meeting, Indianapolis, Ind., October 9–11.

Copies of the supplement will be available some time near the first of February, at which time published copies will be mailed to those who entered advance orders. Others then may obtain copies at 50 cents each from the AIEE order department, 33 West 39th Street, New York 18, N. Y., as long as the limited supply lasts.

The 1946 December supplement will be the final such publication. The new publication policy (*EE, Dec '47, pp 576–8*) in

which the *Proceedings* eliminate the need for monthly *Transactions* also eliminates the need for supplement sections because all discussions are printed with related papers.

## AIEE Nominating Committee for 1947–48 Officers Announced

The nominating committee of the AIEE, in accordance with the Institute's bylaws, will meet during the 1947 winter meeting, January 27–31, in New York, N. Y., to nominate candidates for national offices to be voted on by the membership in the spring of 1947. Members of the committee are as follows:

**Representing the board of directors**

O. E. Buckley, Bell Telephone Laboratories, Inc., New York, N. Y.
R. T. Henry, Buffalo Niagara Electric Corporation, Buffalo, N. Y.
D. A. Quarles, Bell Telephone Laboratories, Inc., New York, N. Y.
L. M. Robertson, Public Service Company of Colorado, Denver, Colo.
E. P. Yerkes, Bell Telephone Company of Pennsylvania, Philadelphia, Pa.

**Representing the ten geographical Districts**

1. F. S. Bacon, Jr., Westinghouse Electric Corporation, Boston, Mass.
2. J. C. Strasbourger, Cleveland, Ohio.
3. J. H. Pilkington, Consolidated Edison Company of New York, Inc., New York, N. Y.
4. C. H. Smoke, Norfolk, Va.
5. J. E. Hobson, Armour Research Foundation, Chicago, Ill.
6. M. L. Burgess, Omaha, Nebr.
7. J. B. Thomas, Texas Electric Service Company, Fort Worth, Tex.
8. D. I. Anzini, General Electric Company, San Francisco, Calif.
9. E. W. Williams, Butte, Mont.
10. L. B. Stacey, Vancouver, British Columbia, Canada.

**Alternates for board representatives**

C. M. Laffoon, Westinghouse Electric Corporation, East Pittsburgh, Pa.
W. C. Smith, General Electric Company, San Francisco, Calif.

**Alternates for District representatives**

F. A. Hoeke, General Electric Co., Knoxville, Tenn. (District 4).
James Pross, Jr., General Electric Supply Corp., Omaha, Nebr. (District 6).
F. C. Bolton, Agricultural and Mechanical College of Texas, College Station, Tex. (District 7).

## Manufacturers Asked to Aid in AIEE Vacuum Tube Survey

Manufacturers are asked once again for their assistance in connection with the survey of instrument and tube manufacturers currently being conducted by the AIEE to determine the need for electronic tubes with special characteristics.

A questionnaire has been sent to more than 400 manufacturers of electronic instruments. For the survey to be a success, all companies manufacturing equipment using electronic tubes should participate.

Companies which have not received questionnaires may request them from the AIEE Joint Subcommittee on Electronic Instruments, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

# DISTRICT • • • • •

## Southern District Plans Membership Increase

Ways and means of increasing membership of the Southern Sections and Student Branches was the chief topic of discussion at the meeting of the AIEE Southern District executive committee held in October.

Selection of a District co-ordinating committee was completed, and it was proposed that for the next year the committee work at promoting the organization of Subsections. Vice-President H. B. Wolf (F '45) suggested that members of the committee be selected from areas considered prospective locations for new Subsections among which he named: Nashville, Tenn.; Jacksonville, Fla.; Mobile, Ala.; North Carolina; Mississippi; and Roanoke, Va. Those elected to the committee are: F. E. Johnson, Jr. (M '40), C. H. Summers (M '38), W. R. Moyers, Jr. (A '43), C. H. Smoke (M '42), and M. G. Northrop (A '29).

Another membership project discussed was the use of a systematized method of presenting AIEE to Student Branches. The membership committee is preparing a 20-minute talk with slides to be used in the promotion campaign.

Letters have been written to all Sections requesting comments and suggestions for increasing membership together with a goal for the coming year. W. S. Leake (M '45) vice-chairman of the District membership committee asked for a 20 per cent increase in membership, and at his suggestion it was voted that a trophy be purchased to be awarded each year to the Section with the largest increase in membership.

All Sections with the exception of Muscle Shoals were represented at the committee meeting. Representatives present were:

C. F. Sitloh, W. W. Eberhardt, Charles Brasfield, Jr., and M. M. Collins of the Alabama Section; F. A. Hoeke, J. J. Hill, and R. M. Alspaugh of the East Tennessee Section; J. L. Weeks and C. O. Warren of the South Carolina Section; G. F. Price, M. S. Johnson, and R. O. Loomis of the Georgia Section; M. L. Barre and C. H. Summers of the Florida Section; W. S. Leake, F. E. Johnson, Jr., G. H. Hill, and E. I. Blanchard of the New Orleans Section; C. H. Smoke of the Virginia Section; L. W. Anderson and H. Hadsel of the Louisville Section; W. R. Moyers, Jr., of the Memphis Section; G. F. Stratton and E. R. Davis of the North Carolina Section.

Vice-President H. B. Wolf, who presided; Director J. M. Flanigen; B. Barnett, chairman of student activities; and C. B. Galphin, District secretary, also were present.

## South West District Discusses Member Activities

Discussion of joint councils and a description of the work of the joint councils in Houston, Tex.; St. Louis, Mo.; and Kansas City, Mo.; occupied the meeting of the executive committee of the AIEE South West District held in November.

R. C. Horn (M '44) discussed membership activities and stated that there is an excellent opportunity to interest industrial engineers in AIEE activities. All the Sections seemed to agree that dinner meetings help increase the attendance, though the rising cost of meals is a problem. The Tulsa Section reported that its members are holding dinner meetings in a cafeteria, which seems to be an acceptable solution.

Business transacted at the District meeting included the authorization of a Student Branch meeting in the spring of 1947; the decision to hold the next District convention in the spring of 1948 in Oklahoma City, Okla.; and the election as nominating committeeman of J. B. Thomas (F '43).

Present at the meeting, were:

R. S. Kersh and H. C. Dillingham of the Houston Section; C. M. Lytle, J. P. Kesler, and T. L. Jones of the Kansas City Section; R. M. Walker and Oscar H. Gutsch of the New Mexico Section; H. K. Doyle and J. M. Hagler of the North Texas Section; R. F. Danner, W. B. Stephenson, J. L. Jones, H. E. Brashear, and C. L. Farrar of the Oklahoma City Section; O. T. Farry, R. W. Gaskins, and R. C. Horn of the St. Louis Section; O. T. Lodal, R. W. Warner, and S. R. Friedsam of the South Texas Section; E. F. Patterson, S. C. Wright, and L. F. Rylander of the Tulsa Section; and R. F. Finnell and C. W. Halferty of the Wichita Section.

# SECTION • • • • •

## Akron Section Expands Discussion Group Program

Initiated in 1945 with the formation of an electronic technical discussion group, the discussion group program of the Akron Section has expanded to include a power technical group and an industrial practice group.

The two meetings of the electronic group held in 1945 drew attendances of 70 and 69 men. One meeting of this group held in the current season was attended by 105 persons, and a power group meeting was held with 53 men present.

The season plans call for three electronic group meetings, two power group meetings, and two industrial practice group meetings. A. G. Seifried (A '40) electrical engineer for B. F. Goodrich and Company, is in charge of the program. Group chairmen are:

*Electronics*—N. F. Harman, Jr. (A '45) of B. F. Goodrich and Company.

*Power*—M. W. Smith (M '44) of the Ohio Edison Company.

*Industrial Practice*—N. A. Williams (M '38) of the Goodyear Tire and Rubber Company.

**Hamilton Subsection Inspection Trip.** Members of the AIEE Hamilton Subsection were invited to an inspection trip of the plant of Smith and Stone Company, Georgetown, Ontario, Canada, manufacturers of electrical hardware, November 15, 1946. The guests were divided into groups

**(Left to right) G. F. Stratton, Professor W. J. Seeley, AIEE President Housley, and AIEE Vice-President H. B. Wolf at the North Carolina Section meeting**

of ten and provided with guides. Starting through the punch department the groups were shown the various phases of manufacturing the porcelain and steatite parts of electrical hardware, which included the processing of the clay, moulding, and finally the firing, coloring, and glazing. The manufacturing of moulded plastic pieces also was viewed. Trygve Wold (M '44) electrical engineer for the company was introduced to the visitors at the supper served after the inspection tour.

## Denver Section Plans Increased Activities

In response to the exceptional growth of its membership by 50 per cent in the past 18 months, the AIEE Denver Section has launched a new activity program. The Section, which now has a membership of 300, notes that previously it took ten years for the membership to increase by 50 per cent.

Crowded meeting places, difficulty in becoming acquainted with new members, and lack of opportunity for members to participate actively in the affairs of the Section, all were symptomatic of the Section's changing status. Formation of technical groups and Subsections is expected to alleviate these conditions.

Results of a survey revealed that the interests of members were concentrated chiefly in the following fields: power systems, electronics, electric equipment, industrial applications and processes, communications, and instruments and measurements. Sponsors were assigned to these various groups, and the first meetings were scheduled for January 1947.

To serve members living some distance from Denver the opportunities for the formation of Subsections are being surveyed. Casper, Wyo., already has been selected as a favorable location, and establishment of a Subsection is proceeding with the aid of B. A. Fleshman (M '44) of the United States Bureau of Reclamation.

## Hill Stresses Management as Future Concern of Engineers

Industry needs engineers equipped to handle human beings, and the engineer in future years must be prepared to focus much of his attention on men themselves, Lee H. Hill (F '38) publisher of *Electrical World*, declared in an address on "The Engineer as a Manager" at a meeting of the AIEE North Carolina Section held recently at Duke University, Durham.

The problems generated by the widespread growth of unionism must be met by establishment of sound employer and employee relations, Mr. Hill said, and indicated several basic policies essential to this development.

He recommended that attitude as well as ability be considered in selecting men for industry, and that proper placement with provision for appropriate advancement be made. Policies relating to employees should be definite, fairly stated, and well understood by all levels of employees, including the supervisory, he said. Adequate training of the supervising staff in the matter of human relations and job analysis and evaluation to avoid discriminatory pay rates, also were mentioned by Mr. Hill.

AIEE President J. E. Housley (F '43) spoke on "Industry and the Institute," and in the course of his talk stated that from his observations while traveling as president, students were showing more interest in organizational activities than ever before.

Technical papers were presented by R. M. Love, Jr., student at Duke University whose topic was "One Hundred Proof Power" and by Blair Jenkins of the Carolina Power and Light Company, who spoke on "Communications for Electric Utilities."

Among those attending the meeting were: AIEE Vice-President H. B. Wolf (F '45) of the Duke Power Company, Charlotte N. C.; C. W. Moseley (M '44) of R. H. Bolighy, Inc., Charlotte; G. F. Stratton (A '30) of the Armature Winding Company, Charlotte; and Professor W. J. Seeley (F '45) of the Duke University school of engineering.

# ABSTRACTS....

**prepared by the authors of the papers and approved by the technical program committee.**

**TECHNICAL PAPERS previewed in this section will be presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947, and will be distributed in advance pamphlet form as soon as they become available. Members may obtain copies by mail from the AIEE order department, 33 West 39th Street, New York 18, N. Y., at prices indicated with the abstracts. Prices of mailed copies to nonmembers will be twice those for members less five cents.**

**Mail orders will be filled AS PAMPHLETS BECOME AVAILABLE**

## Industrial Power Applications

**47-103—Power Distribution in Textile Plants;** *J. D. McConnell (A '31). 15 cents.* Comments are given on the sequence of development of the power distribution systems used today in cotton mills, together with the parallel developments in mill lighting. Mention is made of some of the problems of operating electric machinery caused by the stock handled and the air-conditioning methods that must be used.

## Instruments and Measurements

**47-104—Air-Borne Magnetometers for Search and Survey;** *E. P. Felch (M '39), L. H. Rumbaugh, W. J. Means, T. Slonczewski, L. G. Parratt, A. J. Tickner. 30 cents.* Air-borne magnetometers developed during the war for the detection of submerged enemy submarines since have become important tools for aerial geophysical exploration. The instruments described utilize the second harmonic outputs produced by the magnetic field in saturated core inductors for field measurement and for control of servo stabilizing systems acting around two axes to maintain the measuring element in

alignment with the earth's field. The field to be measured is compared continuously with that produced in the measuring inductor winding by an accurately controlled direct current. The sensitive element usually is towed in a bomb-shaped "bird" sufficiently removed from the airplane to escape the effects of its magnetic field. A continuous record is produced which, when keyed with position records obtained by photography or shoran, may be used in the preparation of maps of total magnetic field intensity.

## PERSONAL ....

**Lee de Forest** (A '04, M '07, F '18) inventor, engineer, and physicist, who has been called the "father of radiobroadcasting," has been awarded the AIEE Edison Medal for 1946. Mr. de Forest, who now is associated with the American Television Laboratories, Chicago, Ill., has been honored "for pioneering achievements in radio and for the invention of a grid-controlled vacuum tube with its profound technical and social consequences." Born in Council Bluffs, Iowa, August 26, 1873, Mr. de Forest was graduated from the Sheffield Scientific School at Yale University with the degree of bachelor of philosophy in 1896. He received the degree of doctor of philosophy from that university in 1899 and was honored with the degree of doctor of science in 1926. He was awarded the honorary degree of doctor of science by Syracuse University in 1919 and the honorary degree of doctor of engineering in 1937. He worked in 1899 and 1900 in the telephone laboratory of the Western Electric Company, Chicago, Ill., and on the editorial staff of the *Western Electrician*, Chicago. The following year he conducted experiments on wireless telegraph receivers at the Armour Institute, Chicago, where he developed the electrolytic responder. In 1901 he organized the de Forest Wireless Telegraph Company and built apparatus for reporting the international yacht races of that year. From 1902 to 1904 he was occupied with the development of the de Forest wireless telegraph system. He equipped ship and shore stations for the United States Signal Corps, as well as land stations for the Army and Navy, and built several stations in Canada. At the request of the British Government he conducted tests between Ireland and Wales, and in 1903 he established wireless communication between Buffalo, N. Y., and Cleveland, Ohio. When he established his wireless system between Chicago, St. Louis, and Kansas City in 1904, it was awarded the Grand Prize of the St. Louis World's Fair, and Mr. de Forest was presented with the Gold Medal of the exposition. In 1904–05 he designed and directed five long distance wireless stations for the United States Navy. In 1906, Mr. de Forest completed the invention of the grid Audion or 3-electrode vacuum tube as a detector for radiotelegraph. Between 1906 and 1918 he discovered and patented the Audion amplifier as telephone repeater which made possible transcontinental telephone communication. In 1909 he introduced into the United States and perfected the quench spark transmitter for radiotelegraph. He was research engineer with the Federal Telegraph Company, San Francisco, Calif., from 1911 to 1913. After 1913 he developed the oscillating Audion or Oscillion, an electronic transformer of direct into high-frequency currents. In subsequent years he was founder and president of the Radio Telephone and Telegraph Company, the de Forest Radio Telephone Company, and the de Forest Phonofilm Corporation in New York, N. Y., and the Lee de Forest Laboratories, Inc., in Los Angeles, Calif. He holds patents on more than 300 inventions in wireless telegraphy, radiotelephone, wire telephone, sound-on-film talking pictures, high speed facsimile, picture transmission and television, and in radiotherapy. Mr. de Forest has been credited with an impressive list of "firsts" in the development of radio and motion pictures, beginning with his broadcasting by radio of the voice of Caruso in 1910. He arranged the first radio news broadcast in 1916 and the first entertainment programs between 1910 and 1920, and established the first broadcasting station in 1916. He was the first publicly to show sound-on-film motion pictures in 1923. He has been awarded the gold medal of the 1915 Panama Pacific Exposition, the Medal of Honor of the Institute of Radio Engineers, the Elliott Cresson Medal of the Franklin Institute, the John Scott Medal of Philadelphia, the Prix La Tour of the Institute of France, the Cross of the Legion of Honor, and the Silver Plaque of the Modern Pioneer of the National Association of Manufacturers. In 1939 at the New York World's Fair he was honored by de Forest Day during which he was awarded a Scroll of Honor. He is a fellow, a founder, and a past president of the Institute of Radio Engineers, and a member of the Society of Motion Picture Engineers, the Yale Engineering Society, Sigma Xi, and Tau Beta Pi.

**Vannevar Bush** (A '15, F '24) president, Carnegie Institution of Washington (D. C.), and head of the armed services' Joint Research and Development Board, has been awarded the Hoover Medal for 1946. The citation accompanying the award reads: "Engineer, educator, and administrator, who, in critical time of need, was in a most special sense an organizer, guiding spirit, and driving force of the nation's achievements in physical and medical science; to whom, for outstanding public service, is awarded the Hoover Medal for 1946." Doctor Bush, the ninth recipient of the medal was born in Everett, Mass., March 11, 1890, and was graduated from Tufts College with the degrees of bachelor and master of science in 1913; he has received honorary doctorates from that institution and from nine other leading colleges and universities. Previously he received the Levy Medal of the Franklin Institute (1928), the AIEE Lamme Medal (1935), the Holley Medal of the American Society of Mechanical Engineers, the John Scott Medal of the Philadelphia City Trustees (1943), the AIEE Edison Medal (1943), and the Washington Award (1946). His first position was in the testing department of the General Electric Company, Schenectady, N. Y., in 1913. After a short time with the inspection department of the United States Navy, he was appointed to the faculty of Tufts College in 1914 as instructor in mathematics and in 1916 was made assistant professor of electrical engineering. In 1918 and 1919 he was engaged in research on submarine detection for the United States Navy. He was employed as consulting engineer by the American Radio and Research Corporation, Medford Hillside, Mass., from 1917 to 1922. Doctor Bush joined the staff of the Massachusetts Institute of Technology as associate professor of electric power transmission in 1919, becoming full professor in 1923 and vice-president and dean of engineering in 1932. He was elected president of the Car-

negie Institution of Washington in 1939. The late President Roosevelt appointed him chairman of the National Defense Research Committee in 1940, director of the Office of Scientific Research and Development in 1941, and chairman of the Joint Committee on New Weapons and Equipment of the Joint United States Chiefs of Staff in 1942. Particularly interested in the design of scientific calculating instruments, Doctor Bush is the builder of the differential analyzer and the author of "Operational Circuit Analysis" and joint author with W. H. Timbie of "Principles of Electrical Engineering." Doctor Bush is also a director of the Raytheon Manufacturing Company, a trustee of Tufts College, Brookings Institution, and the Woods Hole Oceanographic Institution; a regent of the Smithsonian Institution; a life member of the Massachusetts Institute of Technology Corporation; and a member of the business advisory council of the United States Department of Commerce (1939–41). His society affiliations include membership in the American Association for the Advancement of Science, the American Physics Society, the American Academy of Arts and Sciences, the American Philosophical Society, the American Society of Mechanical Engineers, and the American Society for Engineering Education. He also is a member of Tau Beta Pi, Sigma Xi, and Phi Beta Kappa.

C. P. Yoder

S. B. Williams

M. M. Samuels

H. I. Romnes

**S. B. Williams** (M '37) formerly editor, *Electrical World*, New York, N. Y., has been appointed manager of customer relations for the lighting division of Sylvania Electric Products, Inc., New York. Born in Kansas in 1889, Mr. Williams received the degree of bachelor of literature from Princeton University in 1912 and the degree of electrical engineer in 1914. He has been with the McGraw-Hill Publishing Company, Inc., New York, since 1914. He was assigned first to *Electrical World* and in 1922 became managing editor. He was named editor of *Electrical Record* in 1923 and of *The Electragist* and its successor *Electrical Contracting* in 1924. He was appointed managing editor of *Electrical World* in 1936 and editor in 1938. He served as a member of the AIEE publication committee from 1939 to 1944 and was chairman of the Lamme Medal committee from 1942 to 1944. Mr. Williams is a past president of the Illuminating Engineering Society, a past chairman of the New York Business Paper Editors Association, and a former director of the Chicago Business Publishers Association. For several years past, he has served as secretary of the committee of awards for the James H. McGraw Awards for men in the electrical industry.

**M. M. Samuels** (F '24) formerly chief of the technical standards division of the Rural Electrification Administration, Washington, D. C., has been appointed special engineering consultant to REA Administrator Claude Wickard. Born in Lithuania, Mr. Samuels was graduated from the University of Karlsruhe in 1905. He joined the General Electric Company, Schenectady, N. Y., in 1905. From 1907 to 1910 he was associated with Westinghouse, Church, Kerr and Company and from 1910 to 1931 with the J. G. White Engineering Corporation, both in New York, N. Y. He joined the staff of the Federal Power Commission, Washington, in 1934, and in 1938 was appointed to the operations and engineering division of REA. **J. B. McCurley, Jr.** (A '38, M '44) formerly commander in the United States Naval Reserve and wartime director of the electrical engineering department of the United States Naval Academy, Annapolis, Md., succeeds Mr. Samuels. Mr. McCurley holds the degrees of bachelor and doctor of engineering from Johns Hopkins University and the degree of master of science from Yale University. He was associate editing supervisor for the United States Department of Labor, Washington, D. C., from 1935 to 1937 and was at the Point Breeze, Md., plant of the Western Electric Company from 1937 to 1939. Entering the Navy in 1940, he first was made assistant and then acting head of the electrical engineering department of the Naval Academy. He was discharged from active duty in August 1946. Recently he has been directing a group of engineers experimenting with the proximity fuse at the Naval Ordnance Laboratory, Forest Grove, Md. He is the author and coeditor of a number of engineering manuals.

**F. M. Ryan** (A '19, F '46) formerly radio engineer, American Telephone and Telegraph Company, New York, N. Y., has been named radio co-ordinator for the company. A 1919 graduate of the University of Washington, Mr. Ryan's first association with the Bell System was with the Western Electric Company, New York, N. Y., from 1920 to 1924. After 12 years as electrical design engineer with Bell Telephone Laboratories, Inc., New York, N. Y., he became radio engineer with the American Telephone and Telegraph Company in 1936. He represented the company at international radio conferences in Bucharest, Rumania; Havana, Cuba; and Santiago, Chile, between 1937 and 1940. **H. I. Romnes** (A '41) formerly head of the toll transmission group of the American Telephone company, succeeds Mr. Ryan as radio engineer. Mr. Romnes joined the Bell Telephone Laboratories in 1928, the year he was graduated from the University of Wisconsin. He was transferred to the toll transmission group in the parent company in 1935 and had been head of the group since 1945.

**V. M. Marquis** (A '23, M '31) formerly assistant chief of the division of transmission and hydraulic engineering of the Pacific Gas and Electric Company, San Francisco, Calif., has been appointed systems planning and operating engineer of the electrical engineering division of the American Gas and Electric Service Corporation, New York, N. Y. Mr. Marquis holds the degree of electrical engineer from Stanford University and the degree of master of science from Union College. He was associated with the General Electric Company, Schenectady, N. Y., from 1922 to 1928 and previously was associated with the American Gas and Electric corporation from 1928 to 1942. During the war he served with the Office of Production Management and the Office of War Utilities. He joined the Pacific company in 1945.

**W. F. Cotter** (A '20, M '28) formerly radio consulting engineer, Stromberg-Carlson Company, Rochester, N. Y., has been appointed chief engineer for the Scott Radio Laboratories, Inc., Chicago, Ill. With the Federal Telephone and Telegraph Company, Buffalo, N. Y., from 1922 to 1925, he was associated with the engineering, erection, and operation of the pioneer broadcasting station *WGR* in Buffalo. In 1925 he became chief engineer with the American Bosch Magneto Company, Springfield, Mass., and in 1935 joined the Stromberg-Carlson Company as chief radio engineer. He later was appointed chief engineer. During this association he did pioneer work on frequency modulation broadcasting. Mr. Cotter is a member of the Institute of Radio Engineers and the Rochester Engineering Society.

**E. S. Webster** (A '91, M '07) chairman of the board, Stone and Webster, Inc., Boston, Mass., has retired. Mr. Webster a cofounder of the company, will continue his directorships in the company and its subsidiaries and will be available for consultation. Born in 1867 in Boston, Mr. Webster was graduated from Massachusetts Institute of Technology in 1888. In 1889 he formed the partnership which became Stone and Webster, Inc. Originally specializing in electrical engineering, the firm eventually operated in all branches of engineering. It now has an investment banking subsidiary and one which provides managerial services. Mr. Webster, formerly president of the firm, became chairman of the board in 1941.

**M. F. Skinker** (A '22, F '34) consulting engineer of Montclair, N. J., has been appointed assistant to the chief engineer,

Ansco Division, General Aniline and Film Corporation, Binghamton, N. Y. Doctor Skinker, who was born in Denver, Colo., holds the degrees of bachelor of science (1919) and master of science (1921) from the University of Colorado. As a Rhodes scholar he received the degree of doctor of philosophy from Oxford University in 1924. After his return to the United States he became research engineer for the Brooklyn (N. Y.) Edison Company and served as assistant director of research from 1924 to 1937. In 1937 he was made associate director of research. From 1942 to 1945 he was chief development engineer in the development department of the Federal Telephone and Radio Corporation, East Newark, N. J. He resigned to do independent consulting work in 1945. He is a member of the American Society for Testing Materials and the American Physical Society.

**F. H. Streit** (A '30) formerly of the staff of the War Research Division, Columbia University, New York, N. Y., has been appointed chief design engineer of the Southern Ohio Electric Company, Columbus. Mr. Streit, who was graduated from California Institute of Technology in 1926, commenced his utility career with the Los Angeles Gas and Electric Corporation, and, when the company was sold to the city of Los Angeles, he continued as underground engineer. He took charge of electric operation for the Coast Counties Gas and Electric Company, Santa Cruz, West Indies, in 1937. He went to Honolulu as senior design engineer for the Hawaiian Electric Company, Ltd., in 1939 and in 1943 joined the staff of Columbia University.

**L. B. Le Vesconte** (A '36, M '43) formerly supervisor, network calculator, Illinois Institute of Technology, Chicago, Ill., has joined the electrical engineering staff of Sargent and Lundy, Engineers, Chicago, to work on general power system problems. Mr. Le Vesconte received the degree of bachelor of arts from Macalester College in 1926, and, after completing the training course of the Westinghouse Electric Corporation, East Pittsburgh, Pa., he was assigned to switchgear application engineering and to the protective relay application section from 1927 to 1936. In 1937 he became district central station engineer in the Chicago office of the company. He had been with the Illinois Institute of Technology since 1944.

**R. A. Galbraith** (A '38) formerly of the Harbor Building School of Harvard University, Boston, Mass., has been appointed professor of electrical engineering and chairman of the department at Syracuse (N. Y.) University. Doctor Galbraith holds the degrees of bachelor of science from the University of Missouri and doctor of philosophy from Yale University. He was graduate assistant at the University of Missouri, Columbia, in 1933 and 1934 and in 1934 was appointed assistant in the electrical engineering department at Yale University, New Haven, Conn. He was appointed a fellow in 1936.

**F. D. Knight** (M '25) formerlv assistant to the vice-president, Hartford (Conn.) Electric Light Company, has been elected vice-president of the company. Mr. Knight was graduated from the University of Maine in 1909 and commenced his career with the Stone and Webster Engineering Corporation, Boston, Mass., for which he was construction superintendent. He was superintendent of production for the Boston Edison Company from 1925 until 1941, the year he joined the Hartford Company. He has been active in the work of the national engineering committees of the Edison Electric Institute and the Association of Edison Illuminating Companies.

**Richard Cutts, Jr.** (A '29) manager of sales for the meter section of the meter and instrument division of the General Electric Company's apparatus department, Lynn, Mass., also has been appointed assistant manager of the division. Mr. Cutts, a graduate of Massachusetts Institute of Technology, entered the employ of the company in 1928 and since has been associated with the meter division. **E. J. Boland** (A '29, M '36) formerly assistant sales manager of the instrument section of the division has been appointed manager of sales. Mr. Boland, who is a graduate of Aarhus (Denmark) Technical Institute, has been with the company since 1926.

**C. P. Yoder** (A '16) formerly manager of the commercial and industrial bureau, Buffalo (N. Y.) Niagara Electric Corporation, has formed a sales agency for various types of electric heating equipment and utility line materials. He will represent C. M. Hall Lamp Company, Detroit, Mich.; W. N. Matthew Corporation, St. Louis, Mo.; the Steel and Alloy Tank Company, Newark, N. J., and the Triangle Equipment Company, Inc., Nutley, N. J. Mr. Yoder was head of the standardizing laboratory of the General Electric Company, Erie, Pa., from 1916 to 1926. In the latter year he joined the Erie County Electric Company as power sales engineer and later became sales manager. He had been with the Buffalo company since 1931.

**J. F. Lincoln** (A '02, F '39) president of the Lincoln Electric Company, Cleveland, Ohio, recently was awarded the Samuel Wylie Miller Memorial Medal of the American Welding Society. Mr. Lincoln was honored as one "whose belief in the value of electric arc welding has led him to most effective promotions of its use." Mr. Lincoln, who was sales engineer for the Lincoln company from 1907 to 1911, became general manager in 1914 and president in 1929.

**E. R. Whitehead** (A '30, F '45) research professor of electrical engineering, Illinois Institute of Technology, Chicago, Ill., has been appointed secretary of the Midwest Power Conference. Doctor Whitehead also has been appointed to serve as consultant in electrical engineering to the Armour Research Foundation of the Illinois Institute.

**M. L. Ruggieri** (A '40) formerly chief engineer at the East Stroudsburg, Pa., plant of the Line Material Company, has been appointed plant manager of the company's factory at Birmingham, Ala. He has been with the company since 1929.

**E. F. W. Alexanderson** (A '04, F '24) consulting engineer, General Electric Company, Schenectady, N. Y., has been awarded the Danish Gold Medal by the Royal Danish Academy of Science for his work in the technical radio field.

**A. W. K. Billings** (A '07, F '13) retired president, Brazilian Traction, Light and Power Company, Ltd., Rio de Janeiro, has been made an honorary member of the American Society of Civil Engineers.

**N. H. Coit** (A '29, F '40) formerly president, South Carolina Electric and Gas Company, Columbia, has been made chairman of the board of directors of the company. Mr. Coit had been president since 1939.

**C. A. Mayott** (A '13, M '43) formerly manager, Connecticut Valley Power Exchange, Hartford, is now special assistant to the president of the Hartford Electric Light Company.

**H. B. Allen** (A '44) vice-president, New Jersey Power and Light Company, Dover, has been elected secretary of the New Jersey Utilities Association.

## OBITUARY

**Addams Stratton McAllister** (A '02, M '08, F' 12) president, A. A. McAllister and Sons Company, Covington, Va., died November 26, 1946. He was born February 24, 1875, in Covington, and was graduated from Pennsylvania State College in 1898 with the degree of bachelor of science in electrical engineering and in 1901 received the degree of electrical engineer. He also received from Cornell University the degree of master of mechanical engineering in 1901 and the degree of doctor of philosophy in 1905. He was instructor in physics at Cornell University, Ithaca, N. Y., from 1901 to 1904 and in the latter year was appointed acting assistant professor of electrical engineering. In 1905 he was appointed associate editor and in 1913 editor of *Electrical World*, New York, N. Y. He was a consulting engineer from 1915 until in 1921 he joined the National Bureau of Standards, Washington, D. C. He became head of the Bureau's division of specifications in 1926 and assistant director in charge of the commercial standardization group in 1929. He retired in 1944. Doctor McAllister gained early recognition as author of "Alternating-Current Motors," which became a standard text. He was a prolific writer and contributed numerous articles to technical publications in addition to being the author of several books. He served on a committee of the Council

of National Defense in World War I and was associated with the Ordnance Department of the Army. He was a lecturer at Pennsylvania State College, State College, Pa., for many years. He served as AIEE manager from 1914 to 1917 and vice-president in 1917 and 1918. He was a past president of the Illuminating Engineering Society, a member of the American Association for the Advancement of Science, the American Society of Mechanical Engineers, the American Society for Engineering Education, and the Virginia Historical Society. He also belonged to Tau Beta Pi, Eta Kappa Nu, and Sigma Xi. He was granted a number of patents.

**Charles Edward Stephens** (M '22) retired vice-president, Westinghouse Electric Corporation, New York, N. Y., died November 19, 1946, in Delray, Fla., where he was spending the winter. Mr. Stephens was born November 19, 1882, in Ferris, Tex., and attended the University of Texas. He entered the engineering apprentice course of the Westinghouse Electric Corporation, East Pittsburgh, Pa., in 1900. As section engineer he was given charge of motor insulation in 1905 and of arc lamp design in 1909, and was made manager of the illuminating section in 1916. In 1917 he was transferred to New York as acting manager of the supply division and in 1918 was named manager. He became manager of the central station division and in 1925 was made manager of the Eastern district of the company. He was elected commercial vice-president in 1930 and vice-president in 1932. He retired in 1945. He was AIEE director from 1928 to 1933 and represented AIEE on the American Engineering Council. He was a past president of the Electrical Association of New York and a past vice-president of the Illuminating Engineering Society. He had served as a director of the Electric Railway Equipment Securities Corporation and the Federation Bank and Trust Company of New York.

**Herbert W. Young** (A '05, M '21, F '25) president, Delta-Star Electric Company, Chicago, Ill., died November 25, 1946. Mr. Young was born September 4, 1875, in Hamilton, Ontario, Canada. He commenced his engineering career with the Whitney Electric Instrument Company, Penacook, N. H., where he developed electric instruments for electric furnace applications from 1895 to 1900. He was associated with the General Electric Company at Schenectady, N. Y., and Lynn, Mass., from 1900 to 1903 in the meter engineering department. After leaving that company, he worked with Professor R. A. Fessenden on the development of wireless telegraphy equipment. He was commercial engineer in the Boston, Mass., office of the Westinghouse Electric Corporation in 1906 and in 1907 was sales manager of the Central Electric Company, Chicago. In 1909 he and an associate incorporated the Delta-Star Electric Company, and Mr. Young became its president.

**Howard Orr Stephens** (A '18, M '27) assistant engineer, power transformer engineering division, General Electric Company, Pittsfield, Mass., died May 15, 1946. Mr. Stephens, who was born in Cecilton, Md., January 31, 1884, received the degree of bachelor of arts in 1905 and master of arts in 1908 from Washington College and the degree of electrical engineer from Lehigh University in 1908. He entered the employ of the General Electric Company, Pittsfield, in 1908 as a student in the power transformer test section and was transferred to the power transformer engineering division in 1910. In 1915 he became a section head and in 1931 was appointed assistant engineer in charge of large transformers. He was responsible for the design of the largest and highest-voltage power transformers built by the company. During his career, Mr. Stephens contributed many improvements in core and winding design and was granted more than a dozen patents. He was the author of a number of technical papers and was a past chairman of the AIEE Pittsfield Section.

**Joseph Sachs** (A '92, M '97, F '12) engineer and patent consultant, West Hartford, Conn., died November 15, 1946. He was born in New York, N. Y., August 17, 1871. He commenced his career with the Sprague Electric Motor Company, New York, in 1890 and shortly afterwards joined the predecessor company of the General Electric Company, Schenectady, N. Y. He was assistant editor of *Electrical World*, New York, in 1897 and 1898. He became consulting and chief engineer of the Johns-Pratt Company in 1898, and in 1905 organized the Sachs Company of which he was president and manager and in 1912 the Sachs Laboratories, Inc., which he served as vice-president and manager. Since 1939 he had been consultant to several manufacturing companies. In 1903 he was awarded the John Scott Medal of the Franklin Institute for his contributions in the field of fuse protective devices. Mr. Sachs was credited with more than 250 patents and was a member of the American Society of Mechanical Engineers. He was coauthor of "Electric Boats and Navigation" and at one time was a frequent contributor to technical publications.

**Jack Emmette Jackson** (A '38) consulting metallurgical engineer of Brothers, Oreg., died November 1, 1946. Born May 6, 1910, in Myrtle Creek, Oreg., Mr. Jackson was graduated in 1937 from Oregon State College with the degree of bachelor of science in electrical engineering. From 1937 to 1945 he was engineer with the Caterpillar Tractor Company, Peoria, Ill. He returned to Oregon in 1945.

**Arthur Nelson Butz, Jr.** (A '45) professor of research engineering and associate director of the Naval Ordnance laboratory at Pennsylvania State College, State College, Pa., died December 7, 1946. He was born August 8, 1916, in Allentown, Pa., and was graduated from Princeton University with the degree of bachelor of arts in physics in 1938. From 1941 to 1945 he was research associate with the Harvard University Underwater Sound Laboratory, Cambridge, Mass. He was appointed to the staff of Pennsylvania State College in 1945. Mr. Butz was a member of the Institute of Radio Engineers.

# MEMBERSHIP . . .

## Recommended for Transfer

The board of examiners, at its meeting of December 19, 1946, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute.

### To Grade of Fellow

Bigelow, W. B., asst. chief, engg. div., Rural Electrification Administration, Washington, D. C.
Evans, C. T., consulting engineer, Cutler-Hammer Inc., Milwaukee, Wis.
Langdell, J. C., electrical engineer, the Commonwealth and Southern Corp., Jackson, Mich.
Miller, J. S., Jr., professor of elec. engg., University of Virginia, University, Va.

4 to grade of Fellow

### To Grade of Member

Adkins, P. L., electrical engineer, J. G. White Engg. Corp., New York, N. Y.
Boening, E. F., engineer, Allis-Chalmers Mfgr. Co., Milwaukee, Wis.
Colbert, C. J., changeover engineer, Potomac Elec. Pr. Co., Washington, D. C.
Dewey, C. G., design engineer, General Elec. Co., Philadelphia, Pa.
Elmore, D. R., chief inspector, Press Wireless Mfgr. Corp., Hicksville, N. Y.
Gardner, W. G., supervising engineer, General Elec. Co., Norfolk, Va.
Gieringer, C. K., secretary and chief engineer, The Liebel-Flarsheim Co., Cincinnati, Ohio.
Hammond, R. A., asst. district engineer, General Elec. Co., Chicago, Ill.
Jacobs, E., meter & testing engineer, Shanghai Pr. Co., Shanghai, China.
Jamison, J. S., Jr., assoc. professor of elec. engg., Virginia Military Institute, Lexington, Va.
Johnson, V. T., chief operation div., Rio de Janeiro Tramway, Lt. & Pr. Co., Ltd., Rio de Janeiro, Brazil.
King, G. L., Eastern div. engineer, Oklahoma Gas & Elec. Co., Muskogee, Okla.
LaRosa, L., telephone equipment engineer, New York Tel. Co., New York, N. Y.
Machen, C. R., supt. of distribution, East Bay div., Pacific Gas & Elec. Co., Oakland, Calif.
McGeeney, J. J., plant extension engineer, New York Tel. Co., Brooklyn, N. Y.
McNeil, D. H., electrical engineer, U. S. Rubber Co., Chicopee Falls, Mass.
Mearns, W. J., engineer, Hercules Powder Co., Wilmington, Del.
Menke, O. H., factory supt., Hobart Brothers Co., Troy, Ohio.
Merchant, M. W., field construction engineer, (P4), Rural Electrification Administration, Abilene, Tex.
Nunan, J. K., West Coast sales manager, motion picture div., ANSCO, Hollywood, Calif.
O'Shea, C. L., illuminating engineer, lamp dept., General Elec. Co., New York, N. Y.
Park, R. H., consulting engineer & physicist, Washington, D. C.
Quitter, J. P., development engineer, Sperti, Inc., Cincinnati, Ohio.
Rozier, H. F., superintendent of distribution, Appalachian Elec. Pr. Co., Huntington, W. Va.
Sitz, E. L., associate prof. of elec. engg., Kansas State College, Manhattan, Kans.
Slinger, R. N., application engineer, General Elec. Co., St. Louis, Mo.
Thomson, P. R., asst. construction engineer, Pretoria Portland Cement Co., Transvaal, So. Africa.
Volgovskoy, B., electrical engineer, Allis-Chalmers Mfgr. Co., switchgear div., Milwaukee, Wis.
Williams, W. A., engineer, power transformer engg. div., General Elec. Co., Pittsfield, Mass.
Winther, J. B., chief electrical engineer, Dynamatic Corp., Kenosha, Wis.
Woodson, T. T., designing engineer, home laundry equipment, General Elec. Co., Bridgeport, Conn.

31 to grade of Member

## Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before February 21, 1947, or April 21, 1947, if the applicant resides outside of the United States, Canada, or Mexico.

### To Grade of Fellow

Boveri, T., Messrs. Brown, Boveri and Co., Baden, Switzerland.

1 to grade of Fellow

### To Grade of Member

Andrews, C. W., The Ohio Pr. Co., Canton, Ohio.
Bagnall, R. S. D., Brush Elec. Engg. Co., Ltd., London, England.
Ball, D. F., United Gas Pipe Line Co., Shreveport, La.
Ball, R. C., Cutler-Hammer, Inc., Milwaukee, Wis.
Bizzell, A. M., 1325 Second Ave., Niagara Falls, Ontario, Canada.
Blumberg, L., University of Delaware, Newark, Del.
Boyce, W. H., Delta-Star Elec. Co., Chicago, Ill.
Davis, W. L., Battelle Memorial Inst., Columbus, Ohio.
Deibler, O. M., American Tel. & Tel. Co., Chicago, Ill.
Elliott, W. T., U. S. Engineer Dept., CEW, Oak Ridge, Tenn.
Fuselman, H. H., 420 Congress Bldg., Miami, Fla.
Grossenbacher, O. E., Southwestern Bell Tel. Co., Dallas, Tex.
Gue, E. M., Duquesne Light Co., Pittsburgh, Pa.
Hilbert, E. A., General Elec. Co., Schenectady, N. Y.
Holder, D. H., Louisiana Pr. & Lt. Co., Gretna, La.
Howarth, S., Electricity Commission, Yorkshire, England.
Hunnicutt, T. R., Chas. T. Main, Inc., Boston, Mass.
Johnson, O. K., 638 New England Bldg., Topeka, Kans.
Johnson, R. J., General Elec. Co., Schenectady, N. Y.
Kent, R. S., General Elec. Co., Schenectady, N. Y.
Knolle, H. W., Orange & Rockland Elec. Co., Monroe, N. Y.
Lawson, F. J., H. M. Lobdell Co., Boston, Mass.
Loubris, G. E., Boston Edison Co., Boston, Mass.
Loving, J. J., Jr., 79 North Park Ave., Buffalo, N. Y.
MacArthur, C. A., Ebasco Services, Inc., New York, N. Y.
Manning, E. L., N. Y. State Inst. of Applied Arts & Sciences, Binghamton, N. Y.
McCord, W. O., Jr., Elec. Pr. Board, Chattanooga, Tenn.
Morris, S. B., Dept. of Water & Pr., Los Angeles, Calif.
Oliver, F. J., Gage Publishing Co., New York, N. Y.
Pieksen, G. W., 3020 Olive St., St. Louis, Mo.
Purpura, E. P., Westchester Lighting Co., Mount Vernon, N. Y.
Purton, T. A., Utah Pr. & Lt. Co., Salt Lake City, Utah.
Root, L. W., Standard Elec. Products Co., Dayton, Ohio.
Seely, C. K., Sanderson and Porter, New York, N. Y.
Shepherd, I. B., Southern Bell Tel. & Tel. Co., Nashville, Tenn.
Shih, U.-L., Sung Sing Cotton Mill No. 9, Shanghai, China.
Simmons, A. N., Detroit Edison Co., Detroit, Mich.
Simon, F., Western Elec. Co., Chicago, Ill.
Spann, R. D., R. C. A., Camden, N. J.
Spector, D., Central Union of the Workers Cooperation Productive Societies, Palestine.
Stratton, F. S., Copperweld Steel International Co., Toronto, Ontario, Canada.
Townsend, S. C., Pennsylvania Pr. & Lt. Co., Allentown, Pa.
Watson, H. H., General Elec. Co., Bridgeport, Conn.

43 to grade of Member

### To Grade of Associate

**United States, Canada, and Mexico**

1. North Eastern

Anderson, N. A., (re-election), Norton Co., Worcester, Mass.
Cavendish, L F., Oldbury Electro-Chemical, Niagara Falls, N. Y.
Clark, S. C., Jr., General Elec. Co., Schenectady, N. Y.
Ferdinandus, J. H., So. New England Tel. Co., New Haven, Conn.
Foss, R. A., Boston Edison Co., Roxbury, Mass.
Lanoue, R. O., Western Massachusetts Elec. Co., Greenfield, Mass.
McCahan, A. J., Boston Edison Co., Boston, Mass.
Moore, W. F., General Elec. Co., Schenectady, N. Y.
Morgan, S. S., U. S. Rubber Co., Chicopee Falls, Mass.
Nicol, J., The Employers' Liability Assurance Corp., Ltd., Boston, Mass.
Schaller, F. F., Jr., New England Pr. Service Co., Boston, Mass.
Smith, R. D., New England Appliance Co., Cambridge, Mass.
Zack, A., Sylvania Elec. Products, Salem, Mass.
Zahora, L. J., General Elec. Co., Syracuse, N. Y.

2. Middle Eastern

Chase, T. W., General Elec. Co., Baltimore, Md.
Conley, J. H., Maryland Drydock Co., Baltimore, Md.
Davidson, R. A., AAF, Air Materiél Command, Wright Field, Dayton, Ohio.
Fenstermaker, E. E., Roller-Smith Co., Bethlehem, Pa.
Finch, E. S., Locke Insulator Corp., Baltimore, Md.
Fitzmaurice, E. J., Jr., The Elec. Storage Battery Co., Washington, D. C.
Fohl, L. R., Hilscher-Clarke Elec. Co., Canton, Ohio.
Fulton, W. M., Jr., Reliance Elec. & Engr. Co., Cleveland, Ohio.
Gavin, J. D., E. I. du Pont de Nemours & Co., Wilmington, Del.
Ginn, J., Ohio Bell Tel. Co., Cleveland, Ohio.
Higgins, C. E., Sunshine Biscuits Inc., Dayton, Ohio.
Hurlbut, R., Glenn L. Martin Co., Middle River, Md.
Kaufman, M. G., Naval Research Lab., Washington, D. C.
Kaufman, P., Signal Corps Procurement District, Philadelphia, Pa.
Klein, W. K., Baltimore Transit Co., Baltimore, Md.
Makuh, J., Hickok Elec. Inst. Co., Cleveland, Ohio.
McClure, H. L., Delaware Pr. & Lt. Co., Wilmington, Del.
Neal, R. H., Dayton Pr. & Lt. Co., Dayton, Ohio.
Paine, C. D., Westinghouse Elec. Corp., Cleveland, Ohio.
Rigdon, J. W., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Ruzicka, E. R., Clark Controller Co., Cleveland, Ohio.
Stanton, J. S., Headquarter AMC, Wright Field, Dayton, Ohio.
Starkey, D. E., Adamson United Co., Akron, Ohio.

3. New York City

Baker, P. W., U. S. Rubber Co., New York, N. Y.
Bischoff, W. J., Bell Tel. Co. of N. J, Newark, N. J.
Cesar, E. M., General Die & Stamping Co., New York, N. Y.
Costa, P. J., Sperry Gyroscope Co., Great Neck, N. Y.
Dohn, A. P., N. Y. Tel. Co., New York, N. Y.
Dovi, S. F., N. Y. Shipbuilding Corp., Camden, N. J.
Duncan, H. C., Franque A. Dickins, Brooklyn, N. Y.
Figlia, J. R., Fairchild Camera & Instrument Corp., Jamaica, N. Y.
Ladd, J. H., Arma Corp., Brooklyn, N. Y.
Marshall, S. R. (re-election), 1 Wall St., New York, N. Y.
McMahon, E. J., Du Pont Co., Arlington, N. J.
O'Connor, D. G., Sylvania Elec. Products Co., Bayside, N. Y.
O'Neill, J. H., Jr., Madigan & Hyland, Long Island City, N. Y.
Perkins, T. B., R. C. A., Harrison, N. J.
Quynn, P. L., Federal Tel. & Radio Corp., Clifton, N. J.
Ursic, J. F., Westinghouse Elec. Int'l Co., New York, N. Y.
Wadsworth, J. A., N. Y. Tel. Co., New York, N. Y.
White, R. E., Pan America World Airway System, Long Island City, N. Y.

4. Southern

Chapman, C. S., Coal Iron & R. R. Co., Fairfield, Ala.
Clemens, J. C., Florida Pr. & Lt. Co., Sarasota, Fla.
Evans, J. C., Tennessee Valley Authority, Knoxville, Tenn.
Kelly, T. A., Southern Bell Tel. & Tel. Co., New Orleans, La.
McGinnis, H. N., Louisville Gas & Elec. Co., Louisville, Ky.
Merrill, R. A., Univ. of Chattanooga, Chattanooga, Tenn.
O'Hara, M. B., Tennessee Valley Authority, Knoxville, Tenn.
Pate, W. M., Alabama Pr. Co., Birmingham, Ala.
Quinn, Y. M., Jr., Southern Bell Tel. & Tel. Co., New Orleans, La.
Wallace, I. G., Jr., Duke Power Co., Charlotte, N. C.
Watson, J. E., Tennessee Valley Authority, Chattanooga, Tenn.

5. Great Lakes

Bergland, G. W., Winnebago Rural Elec. Co-operative Assn., Thompson, Iowa.
Birge, C. L., Commonwealth Edison Co., Chicago, Ill.
DeMet, M. C., Illinois Bell Tel. Co., Chicago, Ill.
Fosdal, F. A., Waukesha Motor Co., Waukesha, Wis.
Hassel, E. W., Milwaukee School of Engg., Milwaukee, Wis.
Jepson, T. S., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Jochim, R. C., Electro-Motive Div. of General Motors Corp., LaGrange, Ill.
Karsten, E. E., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Knight, W. A., General Elec. Co., Chicago, Ill.
McHenry, E. L., Standard Oil Co., Whiting, Ind.
Nelson, C. A., General Motors Corp., McCook, Ill.
Pearson, A., Automatic Elec. Co., Chicago, Ill.
Pettit, D. L., Square D Co., Milwaukee, Wis.
Roche, T. E., G. M. Orr Engr. Co., Minneapolis, Minn.
Rogers, M. D., Giffels & Vallet, Inc., Detroit, Mich.
Satterthwaite, F. E., General Elec. Co., Ft. Wayne, Ind.
Sherry, J. D., Joslyn Mfg. & Supply Co., Chicago, Ill.
Shumar, R. F., Dow Chemical Co., Midland, Mich.
Skinner, T. F., General Elec. Co., Chicago, Ill.
Smith, W. J., Westinghouse Elec. Supply Co., St. Paul, Minn.
Subrahmanyam, M. V., Allis-Chalmers Mfg. Co. Milwaukee, Wis.
Truckenbrodt, C. A., General Motors Corp., La Grange, Ill.
Vaughn, J. J., S. & S. Industrial, Detroit, Mich.

6. North Central

Marean, R. P., U.S.B.R. Power System, Casper, Wyo.
McIntosh, L. H., Seminoe Dam, Wyo.
Shafer, G. A., Bureau of Reclamation, Estes Park, Colo.
Thalken, J. B., U. S. Bureau of Reclamation, Guernsey, Wyo.

7. South West

Bassett, J. C., Okla. Gas and Elec. Co., Shawnee, Okla.
Benesch, R. E., Southwestern Public Service Co., Amarillo, Tex.
Bunton, G. R., Southwestern Public Service Co., Plainview, Tex.
Christeinicke, H., Cia. Distribuidora Westinghouse, S. A., Mexico D. F., Mexico.
Echols, B., L. E. Myers Co., Lawton, Okla.
Freeman, V. L., Okla. Gas and Elec. Co., Shawnee, Okla.
Gillespie, C. E., Okla. Gas & Elec. Co., Oklahoma City, Okla.
Heckman, C. J., Dallas Pr. & Lt. Co., Dallas, Tex.
Jenkins, J. E., State Dept. of Health, Bureau of Sanitary Engg., Ft. Worth, Tex.
Johnson, H. E., General Electronics, S. A., Mexico D. F., Mexico.
Lappin, R. W., Okla. Gas & Elec. Co., Shawnee, Okla.
Wright, O. W., Southwestern Public Service Co., Amarillo, Tex.

8. Pacific

Allabough, D. B., San Diego Gas & Elec. Co., San Diego, Calif.
Baumann, O., Jr., North American Aviation, Inc., Inglewood, Calif.
Bliss, M. K., Board of Fire Underwriters of the Pacific, San Francisco, Calif.
Boyce, J. A., Southern Calif. Edison Co. Ltd., Los Angeles, Calif.
Commons, H. E., Douglas Aircraft Co., Inc., Los Angeles, Calif.
Dorsey, J. H., Southern Calif. Edison Co., Ltd., Los Angeles, Calif.
Finley, E. A., City of Pasadena Mun. Lt. & Pr. Dept., Pasadena, Calif.
Franklin, W. C., U. S. Navy Civil Service on Guam, FPO, San Francisco, Calif.
Meneley, W. E., Standard Oil Co. of Calif., San Francisco, Calif.
Qureshi, M. H., Univ. of California, Berkeley, Calif.
Schanbacher, H. A., Dept. of Water & Pr., Los Angeles, Calif.
Straub, A. A., Southern Calif. Edison Co., Los Angeles, Calif.
Sutton, R. D., San Francisco Naval Shipyard, San Francisco, Calif.
Tynes, R. A., Beavers & Lodal, Phoenix, Ariz.
Williams, A. L., (re-election), Dept. of Water and Pr., Los Angeles, Calif.

9. North West

Batcheller, J. R., (re-election), Northwestern Elec. Co., Vancouver, Wash.
Behrens, W. V., U. S. Dept. of Interior, Bonneville Pr. Admin., Portland, Oreg.
Davis, J. L., Pacific Tel. & Tel. Co., Portland, Oreg.
Gibbs, H. W., Northwestern Elec. Co., Portland, Oreg.
Holden, P. B., City of Seattle Dept. of Lighting, Seattle, Wash.
Marshall, J. C., Light Dept., Forest Grove, Oreg.
Richards, C. G., Oregon Pulp & Paper Co., Salem, Oreg.
Richardson, J. M., Rayonier, Inc., Olympia, Wash.
Ross, W. R., General Elec. X-Ray Corp., Seattle, Wash.
Soule, E. F., General Elec. X-Ray Corp., Seattle, Wash.

10. Canada

Cullimore, G., Hydro-Elec. Pr. Comm., Niagara Falls, Ontario, Canada.
Sylvester, I. I., Canadian General Elec. Co. Ltd., Montreal, Quebec, Canada.
Willoughby, R. W., B. C. Elec. Ry. Co., Ltd., Vancouver, British Columbia, Canada.

**Elsewhere**

Cabezon B., R., Fabrica de Cemento de El Melon, Santiago, Chile.
Charlton, O. B., The British Thomson-Houston Co., Ltd., Rugby, England.
Cheng, C. C. Shanghai Pr. Co., Shanghai, China.
Marsden, J., General Elec. Co., Witton, Birmingham, England.
Moore, A. A., English Elec. Co., Stafford, England.
Mulhern, G. M., Electricity Supply Board, Dublin, Ireland.
Pike, D., Royal Naval Volunteer Reserve, Warwickshire, England.
Wilkie, J. F., The United Steel Companies, Ltd., Yorks, England.

Total to grade of Associate
United States, Canada, and Mexico, 133
Elsewhere, 8

# OF CURRENT INTEREST

## GE Engineers Act on Professional Organization

Meeting December 18, 1946, to discuss the organization of the engineering profession, approximately 280 members of the Schenectady (N. Y.) General Electric Engineers' Association expressed their overwhelming support for a course of action similar to "Plan *B*" described by the professional activities subcommittee of the AIEE committee on planning and co-ordination in the April 1946, issue of *Electrical Engineering*, pages 169–73. Ninety-nine per cent of the group attending the meeting favored the rapid formation of a national society to raise the professional and economic status of all engineers, a society which would *supplement* the technical activities of the existing societies. The following report was prepared for *Electrical Engineering* by G. E. Walter (A '44) of the AIEE Schenectady Section, who is chairman of the national association and legislation committee of the SGEEA.

Reactions of SGEEA members were determined at the meeting by a poll which showed also that 97.5 per cent wanted the National Society of Professional Engineers to act as the nucleus for this new society and that 92 per cent agreed that all eligible SGEEA members should obtain professional licenses under the New York State law. Eighty-eight per cent of the questionnaires were unanimous in support of the three proposals.

The meeting was sponsored by the national association and legislation committee of the SGEEA, which has been interested for three years in the formation of a single national society to promote the professional and economic status of engineers. Speakers were W. F. Ryan of the Stone and Webster Engineering Corporation, Boston, Mass., and C. W. Ransom (A '36) of the General Electric Company, Pittsfield, Mass.

A noteworthy aspect of Mr. Ryan's address, during which he described the requirements and benefits of a professional organization and showed how the organization of the NSPE placed that society in a position to handle professional and economic problems, was his selection December 6, at the NSPE 1946 annual meeting, as the chairman of a special committee to investigate what the NSPE could do to assist in the formation of the type of society proposed by the Schenectady association.

Mr. Ransom, the other speaker, directed the preparation of the paper, "An Immediate Measure to Strengthen the Professional and Economic Position of the Engineering Profession." Supported jointly by the GEEA at Lynn, Mass.; Fort Wayne, Ind.; Pittsfield; and Schenectady, the paper appeared in *Mechanical Engineering* for September 1946, and was presented by Mr. Ransom at the October convention of the American Society of Mechanical Engineers in Boston.

This paper summarizes many of the reasons which have been used by the General Electric associations to support their status as groups which are actively interested in the professional and economic problems of engineers but which do not favor or engage in collective bargaining. The paper also discusses the need for improving the economic position of engineers and strengthening the profession by establishing a professional and economic "division" of the various technical societies.

On the basis of this paper, Mr. Ransom's discussion of the rapid developments that have followed its publication, and Mr. Ryan's support of the NSPE, members of the Schenectady association stated their approval of the recommendations offered to them December 18. In full, these recommendations were:

1. That the Schenectady General Electric Engineers Association actively support the formation of a single national professional and economic "division" to promote the professional status, personal development, engineering efficiency, contribution to society, and economic status of all engineers.

2. That the National Society of Professional Engineers be given first consideration as the nucleus of this professional division.

3. That all eligible Association members registered as professional engineers under the New York State law.

At the December 18 meeting, President E. H. Bancker (M '30) of the Schenectady association announced that in the near future all 1,500 members would be polled on these recommendations. Plans for carrying them out will be directed by the national association and legislation committee, consisting of A. W. Bedford, Jr., W. C. Hahn, A. J. Lee (A '45), T. M. Linville (M '34), and G. E. Walter (A '44), chairman.

### Betatron Demonstrated for Ordnance Inspection

The radiography laboratory of the Picatinny United States Army Arsenal, Dover, N. J., was the site of a demonstration on November 14, 1946, of a 20-million-electron-volt betatron manufactured by the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., for use in thick-section radiographic inspection of ordnance matériel. This was the first demonstration of the equipment which was kept secret during the war because of its close association with nuclear physics and the atomic bomb A description of the apparatus in "Application of the Betatron to Practical Radiography" by J. P. Girard (A '45) and G. D. Adams appeared in AIEE *Transactions*, volume 65, 1946, May section, pages 241–6. Doctor D. W. Kerst of the University of Illinois, Urbana, who invented the first successful betatron, said in a short talk before the demonstration that he considered the betatron to have three important possible uses:

1. For industrial radiographic inspection.

2. In medicine, especially for treatment of cancer.

3. For science as an X-ray and electron source with precision control, and as a laboratory source of cosmic rays at energies of 250 million electron volts or more.

The unit at the Picatinny Arsenal is quite simple in operation. First step is to close the auxiliary circuit switch to warm up the filaments. Then the exposure control is set according to the radiation required for examination of the object. When the filaments are prepared to operate, the magnet is energized and the injection voltage is increased slowly until full X-ray yield is obtained. After exposure has been completed the magnet power is switched off automatically. As a safety precaution all doors leading to the X-ray room are equipped with indicating lights and switches which are interlocked electrically with the betatron main power switch.

### Hydroelectric Development in Germany Described

Development of the electric power generating facilities of Germany during the war was dependent upon the need to conserve natural resources, particularly coal, A. Hoefle, superintendent of the system operations department of the Toledo (Ohio) Edison Company, explained recently at the hydraulic session of the annual meeting of the American Society of Mechanical Engineers in New York, N. Y.

However, the available undeveloped sites required great quantities of such scarce items as steel, cement, copper, and aluminum. "The extent to which one scarce commodity could be allocated to conserve a more plentiful one presented the planning authorities with many neat headaches," Mr. Hoefle stated.

Control of Germany's utilities was complex and ever-changing, but the objective was constant, namely, to assure a plentiful supply of uninterrupted power at a minimum cost to the nation's wealth of resources and man power. Excellent communication facilities made it possible to maintain an almost hourly control of the entire national situation, an advantage

which proved invaluable during the interruptions caused by Allied air raids.

Mr. Hoefle described the nation-wide transmission grid of Germany. Three-phase alternating current at 50 cycles is standard for the country. Voltages range through the lower and intermediate levels to the upper values of 110 and 220 kv. Several 220-kv lines were constructed whose sole purpose was back-up service in event of air-raid damage. Experiments also were actively under way on d-c transmission at very high voltages.

Generating plants were built at mouths of coal mines or at load centers. Stein coal, which corresponds closely to United States bituminous coal, is very plentiful in the Ruhr district and to a lesser extent in the Saar and in Silesia. Important fields of brown coal, which also is plentiful, lie near Cologne, central Germany, Silesia, and in scattered fields elsewhere.

The hydroelectric resources of Germany are 60 per cent developed, Mr. Hoefle revealed. In 1944, approximately 12 per cent of the country's generation was hydroelectric. Most of the developments are small stream flow stations which may be combined with navigation flood control and other functions.

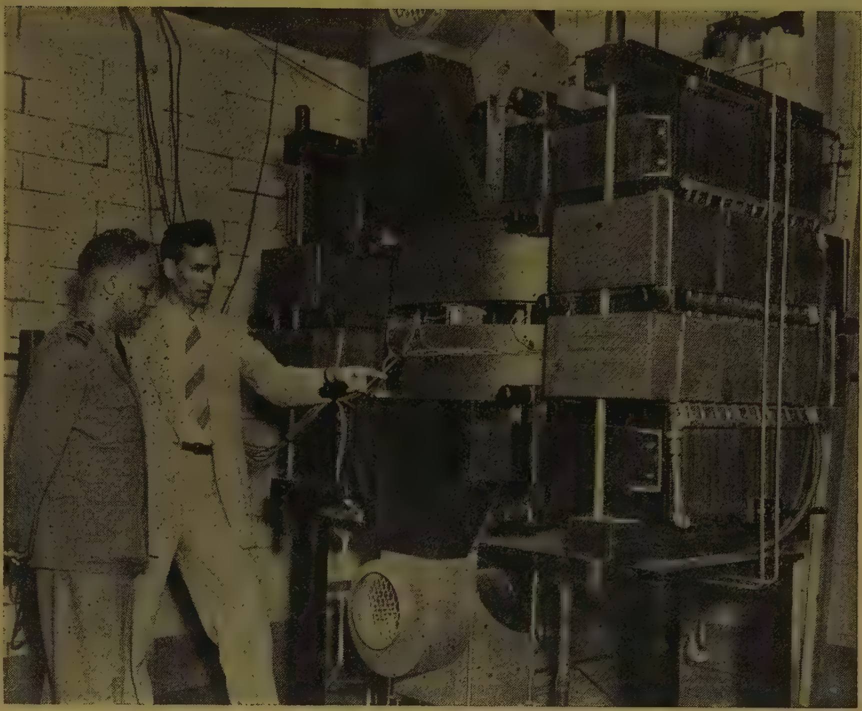
One development caused by scarcity of materials was described as the so-called underwater turbine. In this unit, the rotor of the turbine becomes the spider of the generator. The result is a small compact unit easily installed within the dam.

Pumped storage hydroelectric stations are popular, it was brought out. Eight such stations varying in size from 40 to 220 megawatts have been built. In these stations an elevated storage reservoir is filled with electrically driven pumps. Pumping energy is off-peak energy derived from stations fired with brown coal the characteristics of which demand as nearly straight line loading as possible.

Bomb damage to hydroelectric stations was practically negligible, largely because of their small size and wide dispersion.

Mr. Hoefle, a lieutenant colonel in World War II, served two years with the Supreme Headquarters of the Allied Expeditionary Forces.

## New 70-Million-Electron-Volt Synchrotron



**This 70-million-electron-volt synchrotron was developed jointly by Doctor H. C. Pollock and W. F. Westendorp (M '43) of the General Electric Research Laboratory, and built at Schenectady, N. Y., as part of a project sponsored by the Office of Naval Research. As originally proposed the synchrotron was invented independently by V. I. Veksler of Russia and E. M. McMillan of the University of California, Berkeley. The new addition to the field of atom-smashing devices combines certain features of the several-thousand-ton cyclotron and the hundred-ton-or-lighter betatron. Electrons are accelerated initially in the synchrotron, as in the betatron, by being injected from a hot filament and speeded up as the magnetic field builds up. When the electrons have acquired sufficient speed, approximately 97 per cent of the speed of light, a 163-megacycle oscillator automatically takes over and continues the accelerating process in the same manner that the cyclotron accelerates heavier atomic particles. For production of X rays termination of the radio-frequency oscillations permits the orbits to contract so that the electrons bombard a platinum target. Doctor Pollock states that the success of the apparatus indicates the possibility of producing radiations of higher energies than 70 million electron volts for atomic study**

## Standard Yarn Numbering for Electrical Industry

A proposal for a standard system of numbers for textile yarns used in the electrical industry is made in the October issue of *Industrial Standardization* by A. A. New of the engineering staff of Standard Telephones and Cables, Ltd., London, England. Mr. New's suggestions come as the American Society for Testing Materials gives its official approval to the Grex Universal Yarn Number System, a system which meets many of the requirements outlined by Mr. New.

Mr. New points out that the electrical industry is particularly vulnerable to the multiplicity of yarn numbering methods, because of the wide variety of sizes as well as fabrics which may go into one company's cable output. The situation also unduly complicates personnel training and selection. In conclusion he enumerates the following five points which should be considered in adopting a single count system:

1. The natural thing is to expect a large number to stand for a large or coarse yarn and a small number for a fine one, or in other words, that the count numbers should vary as a direct function of the size or weight of the yarn; that is, like the denier system and not as an inverse system like the cotton and worsted counts.

2. As the industry is at liberty to choose any numbers, the choice should be the very simplest to calculate and remember, such as the weight per 1, 10, 100, or 1,000 units of length.

3. Since the metric system of weights and measures is taught in the schools in Great Britain, is well established in scientific work, in that country, and for general purposes on the Continent, and export trade is going to be very important in the future, a metric basis seems preferable.

4. A universal system for all textiles includes a very large range of magnitudes. For this reason, the fine silks or cottons at one end of the scale would be hampered by the use of fractional counts, or the coarse jute yarns at the other end would have inordinately large count numbers. This difficulty might be overcome simply by basing the count on the weight of one kilometer of the yarn in grams or kilograms, a "1,000" yarn being called an "IK." This would mean that the finest silks and

cottons would be about 1s, or 2s while the coarsest jutes (used in electrical work) would become about "30K." Such a system is merely the present metric denier system with the count numbers divided by 9. It may be argued that this makes the counts of filaments of rayons have numerical values less than 1. This would be avoided by using a 10-kilometer base which would mean that the count numbers would be very close to the present metric denier count (actual 10X). This consideration does not seem important however compared with the simplicity of the "grams per kilometer" basis.

5. With regard to the method of expressing plying, the only logical way is surely that 2/10's means a 20's. This is a characteristic of the weight per unit length systems and not of the length per unit weight systems with their anomalous principle that "two tens is a fives."

**Electric Railways for England.** Plans for the complete electrification of the 2,156 route miles of the Southern Railway of Great Britain, from the Kent Coast to Cornwall, have been announced by the British Railways in New York, N. Y. Work on the first part of the scheme, which will include all southeast England, will start within the next six months and will cost approximately $75,000,000. The first new section to be electrified will be the route of the London–Paris boat train, *The Golden Arrow*, between London and Dover. The lines between London and Ramsgate, Hastings, and Folkestone will be next, and then an alternative London–Brighton line. This much of the system is to be finished by 1955, after which the western section between London and Cornwall will be started. Already 150 electric locomotives of 600 horsepower with a top speed of 75 miles an hour have been ordered for passenger service. Electrical haulage of freight trains is planned, and the switching in freight yards will be carried out by 100-ton Diesel-electric locomotives, orders for 200 of which already have been placed.

## Teleran Developed as Air Navigation Aid

Details of teleran, an aid to safe avigation which evolved from wartime radar developments, recently were revealed by the Radio Corporation of America in connection with the first public test of the system at the Indianapolis Airport.

Teleran, derived from the words, "television–radar air navigation," provides in pictorial form all the information a pilot needs in the air. It does this irrespective of visibility, and is believed to have a range of 30 to 50 miles. It is presented as the solution to all problems of air navigation, traffic control, collision prevention, and instrument flight.

By this newly developed system, a ground radar unit scans the sky and ground area of the airport and collects information which is delineated on radar scopes in the form of the familiar radar pattern. One indicator is used for each altitude layer. What the radar reports is collated at the ground station from time to time or continuously as requirements may dictate. Television cameras are trained on the radars, and the whole is transmitted as a motion picture to a scr en mounted on the airplane's instrument panel. The pilot need only glance from time to time at the television receiver screen to see the whole picture of his surroundings: other nearby airplanes; the runways on the field; all towers, buildings, and other obstructions; direction of flight; and other geographical and meteorological data; as well as traffic control directions from the ground control officer in charge. He sees also his own airplane in flight and its position with respect to other airplanes and the earth. Signals received from each airplane over the field are separated electrically from each other and sent out as a composite elevation signal.

Development of the system now is being carried on largely under contract with the Army Air Forces. Loren F. Jones of the RCA engineering products department was responsible for the basic idea of the system, and Doctors Douglas Ewing, Vladmir K. Zworykin (F '45), Irving Wolff, and P. J. Herbst were associated with its development.

## Enemy Equipment and Documents Available at Wright Field

From September 9 to 13, 1946, the United States Air Technical Intelligence held a symposium at Air Matériel Command headquarters, Wright Field, Dayton, Ohio, to facilitate exploitation of enemy equipment and data (*EE, Aug-Sept '46, pp 425–6*).

To utilize the benefits of foreign efforts, Air Technical Intelligence works closely with industry, educational centers, and other Government agencies. These organizations may obtain reports made on equipment after analysis by intelligence, or they may borrow the equipment and conduct their own research.

Most of the scientific papers and technical documents can be obtained on request. Those reports which have not yet been translated also can be obtained if the borrowing organizations agree to return translated copies. The Wright Field Air Intelligence Library has some of the only copies of work done in foreign research and their use is restricted to the library area.

A comprehensive set of bibliographies and a card index have been completed by the Air Documents division and wherever possible these are being made available to agencies requesting them for their research.

To receive the best service a requesting organization should first obtain the catalogue which has been prepared. All correspondence should be directed to: Commanding General, Air Matériel Command, Wright Field, Ohio, Attention: Air Technical Intelligence (*T-2*).

## Civil Service Openings for Engineering Positions

The United States Civil Service Commission is accepting applications to fill responsible positions in all branches of engineering in the Federal service in Washington, D. C. The majority of the positions are in the War Department, Navy Department, Department of the Interior, Department of Commerce, Department of Agriculture, and Federal Works Agency. The salaries range from $7,102 to $9,975 a year.

To qualify for these positions, applicants must meet one of the following basic requirements:

1. Completion of a standard professional engineering curriculum leading to a bachelor's degree.

2. Four years of progressive tehnical engineering experience.

3. Any combination of (1) and (2). In addition, they must have had four years of broad and progressive professional engineering experience.

Appropriate graduate study may be substituted for part of this experience.

A written test is not required for this examination; applicants will be rated on their experience and training. The maximum age limit, 62 years, is waived for persons entitled to veteran preference.

Applications will be accepted in the United States Civil Service Commission, Washington 25, D. C., until further notice. Further information and application forms may be secured at most first- and second-class post offices, from the Commission's regional offices, or from the Commission's office in Washington.

**USA First to Ratify ISO.** The United States has become the first country to ratify the convention setting up the 25-nation International Organization for Standardization (*EE, Jan '47, p 106*), P. G. Agnew (M '19) vice-president and secretary of the American Standards Association, has announced. Doctor Agnew revealed that 64 projects now have been accepted for ISO action, and 17 nations have undertaken the technical leadership in one or more of these projects. Technical leadership is being assigned to countries in which the industry covered by a project is well developed. The countries and their projects follow: metal food containers, iron and steel, rubber (United Kingdom); methods of testing petroleum products, agricultural machinery, still photography, moving pictures, definition of the term "rayon" (USA); timber grading and classification of defects, surface finish of metal surfaces (Union of Soviet Socialist Republics); metric and inch threads, ball and roller bearings, modular building planning (Sweden); bolts and nuts (Poland); sheet and wire gauges (Australia); gears, couplings, commercial zinc (Belgium); nonmetallic packaging of frozen foods (Norway); limits and fits, tools, automobiles, machine tools, tests for building materials (France); aircraft and airfield lighting, copper and copper alloys (Canada); ocean

navigation, pigments, raw materials for paints, rivets (Holland); pipes (Switzerland); shellac, mica (India); methods of analysis of essential oils (Brazil); sprinkler plants (Austria).

**Television Demonstration in Mexico.** Television broadcasts staged by the Radio Corporation of America as a feature of the first Inter-American Broadcast Congress held recently in Mexico, Federal District, Mexico, were received with enthusiasm by large audiences. The first televised bullfights were transmitted from the Plaza Mexico, which seats 60,000, and the program was sent by microwave radio relay to an audience of 7,500 at the Hotel del Prado, six miles away. The RCA Image Orthicon camera was placed facing the gate where the bulls charge into the arena. Monitoring equipment was placed a little farther up the side of the stadium, and a portable microwave radio relay parabola was installed near the rim of the bowl to permit line-of-sight transmission to a receiving reflector on the roof of the Prado. No special lighting was required. Fashion shows and other subjects also were presented by television during the 5-day exhibition, which drew a total audience of 32,500 persons.

**"Radar" Trade-Mark Restricted.** Protests of the Radio Manufacturers Association against an attempt to secure a trade-mark of the general term "radar," which was made through the American Embassy at Madrid, Spain, have resulted in notification from the Spanish authorities that trade-mark rights on the term will not be permitted in Spain in relation to radio or any other electric apparatus. The term will be applied only to mirrors, glassware, and similar items. RMA action was taken through the United States Departments of State and Commerce.

**Marine Technical Group.** Organization of a new government and industry technical advisory group on electronic marine and navigation problems, similar to the present Radio Technical Commission for Aeronautics, was effected at a recent conference in Washington, D.C. In the marine field and on problems of marine equipment, also possibly on navigation and commercial problems, the new technical advisory committee is expected to function similarly to RTCA. Future consolidation with RTCA is envisaged. A score of representatives of government departments and agencies, also of industry organizations, attended the marine group organization conference called by the State Department. The chief of its telecommunications division, Francis Colt de Wolf, presided. A committee was appointed to draft a tentative constitution and bylaws for the new electronic technical commission for marine interests.

# Engineering Foundation Reports on Finances and Status of Projects

The yearly report of the Engineering Foundation was submitted by Chairman A. B. Kinsel and Director E. H. Colpitts (F '12) at the annual meeting of the foundation.

The book value of the capital funds of the foundation on September 30, 1946, was $944,242.28 as compared with $940,909.49 on September 30, 1945. The income for the fiscal year 1945–1946 was $33,850.21 as compared with $34,536.89 for the previous year 1944–1945. For the fiscal year 1945–1946 disbursements amounted to $32,511.23 as compared with $28,675.22 for the year 1944–1945. The balance on September 30, 1946, was $48,215.50 as compared with $46,876.52 on September 30, 1945.

As this report indicates, the foundation, during the year, has continued its policy of supporting research projects in various fields of engineering and also certain agencies or activities having as their objective the advancement of the engineering profession. In selecting projects to be supported, preference has continued to be given to those of a more fundamental nature which normally would not be undertaken by an industrial research organization. Where a project is of interest to a group of industries the foundation has provided limited financial support and a sponsorship which enabled the main support of the project to be secured from industry or other sources. In general, it should be understood, the grant of the foundation merely supplemented the contributions of the organization carrying on the research. Such contributions were space, testing facilities, technical direction of project, and the like. Thus supplemented, relatively small grants from the foundation were made most effective.

As to present-day conditions affecting industrial and scientific research, the United States is faced with an immediate shortage of highly trained research personnel. This situation promises to be relieved in several years time, as large numbers of students are undertaking graduate work in the universities which, it may be added, are finding it difficult to secure adequate staffs due to the severe competition for trained men from Government and industry. It is clear that industry in general has become more research-minded, and large expansions of industrial research are to be expected. In some cases this will be by individual companies, in others by associations of various types. The impact of this situation on foundation activities is being considered carefully.

Both of the armed services have undertaken to support large research projects under contracts with universities and industrial organizations. To what extent in the future and by what mechanisms government will support research is still uncertain, but it is reasonable to expect that, whatever plan finally is adopted, there will remain important areas where organizations such as the foundation can serve provided their financial resources are adequate. Representatives of the Armed Forces were present at the annual meeting to discuss the foundation's relation to their work.

During the year 1945–1946 work under 14 projects has continued. For the year 1946–1947 grants have been recommended to enable continuation of nine projects and for the initiation of four new projects.

*Welding Research Council, Project 62.* Officers for this project are:

*Chairman*—Doctor Comfort A. Adams (F '13) Edward G. Budd Manufacturing Company, Philadelphia, Pa.

*Vice-Chairman*—H. C. Boardman, Chicago (Ill.) Bridge and Iron Company.

*Director*—W. Spraragen (M '26) 29 West 39th Street, New York 18, N. Y.

During the year the sponsorship of the Welding Research Council was broadened to include all the four Founder Societies as well as the American Welding Society.

The Welding Research Council in the short period of about ten years has grown from a small beginning (a contribution of $5,000 from the Engineering Foundation) to having an annual budget of about $250,000. Prior to the war it had engaged some 300 of the ablest men of this country, interested in welding research and related science. It had developed research centers in perhaps 30 laboratories mostly in the universities. Already much had been accomplished in the way of research results and many of the research problems formulated which soon became apparent as needing solution for the war effort. All these were made available to Government agencies and were employed most importantly by them. Much of the research which came to be sponsored by the Government was confidential, but the results now are being declassified and being made available through the council to industry.

Reconversion finds the council in position to set up its projects on a long term basis aimed at solving the complex problems clearly seen as confronting the welding industry. During the year particular effort was made to stimulate research in the universities.

The council during the year has continued to operate through a number of committees of which the following are the principal:

Aircraft welding research (now consolidated with resistance welding research).
High alloys committee.
Resistance welding research committee.
Universities research committee.
Fatigue testing (structural) committee.
Structural steel research committee.
Weldability committee.
Weld stress committee.
Pressure vessel research committee.

The *Monthly Research Supplment* one of the council's publications totals for the year a volume of over 700 pages, and in addition the council provides its contributors and re-

search workers with mimeographed copies of bulletins containing current information on researches in progress.

*Technical Services Investigation in Germany, Project 92.* This project, the Technical Industrial Intelligence Branch of Office of Declassification and Technical Services in United States Department of Commerce has the stated purposes of an investigation and evaluation of German developments during the war years in scientific personnel, management, and industrial training in order to select and integrate these with advancements in the United States and other countries.

The proposed investigations are to be carried out by expert personnel "detailed" to the Department of Commerce. These experts will be proposed by and represent, possibly an industry, an association, a Government Department, or other organization, such as a university. The grant made by the foundation was requested by the American University, Washington, D. C., and is intended to pay in part the expenses of Doctor Morris S. Viteles, who has been selected by that university for this "detail."

As this project was initiated late in the fiscal year, no progress report can be made.

# Annual Report Shows Increase in Engineering Library Use

Use of the Engineering Societies Library in 1945–46 was 15 per cent greater than in the previous year, according to the annual report submitted by Ralph H. Phelps, director of the library. An average of 130 persons have been served by the library each day. All services have had greater use, except the photostat service which has decreased about nine per cent. This is explained by the fact that it had experienced an abnormal growth during the war.

In this year of change, uncertainty, and difficulty, there have been staff changes, and supplies, equipment, and binding have been uncertain and difficult to get. Books, magazines, and reports unavailable during the war now are coming in a rapidly increasing flood that will continue for some time.

### PERSONNEL

On February 1, 1946, Doctor Harrison W. Craver, director of the library since 1917, became consulting librarian. At the same time, Ralph H. Phelps was made acting director of the library. Later he was appointed director. A dinner honoring Doctor Craver was held May 22, 1946, at the Engineers' Club in New York, N. Y. Those present included present members of the United Engineering Trustees, Inc., and members of the library board since 1940.

### FUNDS

The Library received $10,000 from the estate of W. S. Barstow. This was added to the endowment fund. The interest from this fund and the receipts from a large sale of duplicate books, together amounting to over $2,000 provided an unexpected addition to operating revenue. Contributions from other engineering societies, although small in comparison with funds supplied by the Founder Societies, have been very helpful and are much appreciated.

More than 4,000 duplicate books and periodicals from the collection of John R. Freeman were made available to the International Relations Committee of the Engineers' Joint Council. Most of the books were shipped to China, but others went to libraries in various countries. These shipments were made through the American Book Center.

The Association of Research Libraries this year dropped the Engineering Societies Library from its membership. This action was taken after a survey disclosed that this library spent much less for books and magazines than other libraries in the association. The Engineering Societies Library always has been able to operate with a small expenditure for books, because it has been favored particularly by gifts of recent publications. Having a relatively narrow field to cover, compared with the very large libraries that compose the Association of Research Libraries, it has been able to keep abreast of affairs in its field, engineering. It is becoming increasingly difficult to do so, owing to increased research activity in its field, and the question of its adequacy needs careful review by the board.

At the direction of the library board, the director made a survey of salaries of other libraries and of the Founder Societies. Engineering Societies Library salaries were lower than others. Adjustments have been made and, salaries now are comparable.

Engineering Index cards for the current year now are filed in the reading room. Thus, this valuable index becomes immediately available to members and engineers, which previously was not the case.

### USE OF THE LIBRARY BY NONVISITORS

"The requests of the nonvisitors for loans of specific books, advice as to the best or most recent book on a specific subject or in a specific field, sources of information, specific data on manufacturing problems, and miscellaneous appeals, each requires on the average much more library staff time than would be needed if the inquirer came to the library. In this respect, nonvisitors are receiving a much greater service relative to that received by visitors than would be indicated by the ratio of the numbers of each, so that is is certainly not true that those living in the metropolitan area benefit much more by library expenditures than those living beyond visiting distances," the director said.

### PROMOTION OF SERVICES

A folder describing the services of the library was prepared and printed, and several thousand copies have been distributed. It is a great help in answering the many inquiries about the services of the library. The folder has been reprinted in the journals of the Founder Societies (*EE, Aug-Sept '46, p 424*).

The director attended the summer meetings of The American Society of Mechanical Engineers and AIEE in Detroit, Mich., and had an opportunity to tell some of the members of these societies about the services of the library.

### ACQUISITIONS

During the year, 10,739 volumes, pamphlets, maps, and so forth were received; of these, 6,655 were added to the library. (These items are respectively 15 per cent and 23 per cent greater than last year.) The remainder, being duplicates or work of no value to the library, were given to other libraries or reserved for sale or exchange as opportunity arises. The library has entered into negotiations for thousands of foreign books, and also all Office of Scientific Research and Development reports.

Total resources at the close of the year were 161,884 volumes, 10,663 maps, and 4,838 searches—a total of 176,785 items.

During the year, a large number of gifts were received. Specific mention is made

**Operation of Library 1945–46**

| | | |
|---|---|---|
| Maintenance revenue | $53,263.13 | |
| Maintenance expenditures | 51,748.11 | |
| Credit balance for year 1945–46 | $ 1,515.02 | |
| Credit balance from previous years | 8,146.70 | |
| Credit balance September 30, 1946 | | $ 9,661.72 |
| Service bureau revenue | $20,285.41 | |
| Service bureau expenditures | 16,900.39 | |
| Credit balance for year 1945–46 | $ 3,385.02 | |
| Credit balance from previous years | 12,544.22 | |
| Credit balance September 30, 1946 | | $15,929.24 |
| Total net operating credit balance cumulated to September 30, 1946 | | $25,590.96 |

**Library Services**

| | | Change From Last Year, Per Cent |
|---|---|---|
| Visitors served, total | 23,009 | 11, increase |
| Nonvisitors served, total | 14,750 | 11, increase |
| Photostat orders | 3,989 | 5, decrease |
| Photostat prints | 47,932 | 9, decrease |
| Microfilm orders | 86 | 45, increase |
| Searches | 140 | 38, increase |
| Translations | 76 | 17, increase |
| Words translated | 218,577 | 22, increase |
| Borrowers | 1,253 | 8, increase |
| Books lent | 1,772 | 9, increase |
| Telephone inquiries | 6,704 | 20, increase |
| Letters written (exclusive of book orders) | 2,503 | 22, increase |

of gifts from M. N. Baker through the American Water Works Association, George G. Berger, C. H. Brandes, R. H. Goodwillie (A '04), Edmund D. Haigler (M '45), John M. Lovejoy, James A. Rabbitt, George J. Taylor, and Professor Edy Velander (M '44). Other donors included the Franklin Institute, the General Cable Corporation, Lehigh University, the McGraw-Hill Publishing Company, Purdy and Henderson, *Railway Age*, Society of Automotive Engineers, the Alloys of Iron Research, the American Society for Metals, the American Society for Testing Materials, the American Water Works Association, the British Information Services, and the Society of Naval Architects and Marine Engineers.

# Space for Founder Societies Major Problem of UET in 1945–46

The problem of more adequate housing for the Founder Societies and associated societies which occupy the Engineering Societies' Building remains the chief concern of the United Engineering Trustees, it was revealed in the annual report of UET President J. P. H. Perry.

The need for additional area has forced two of the Founder Societies to take considerable space in adjacent buildings. Since June 1946 a committee has been at work on studies for the Founder Societies' approval which may develop into plans which will furnish them the increased space they so urgently need, whether in the present building with reconstruction, and perhaps acquisition of adjacent properties, or in a new building at a different location.

The building is occupied fully by the four Founder Societies and nine associates, with demand for an additional 10,000 square feet at once, and still more in the coming five and ten years. The building, designed early in the century, is difficult to adapt to present sound office practice. Illumination gradually is being modernized and a general demand for air-conditioned space is expected in the future.

Notwithstanding its age the building is in excellent condition. Its age has shown in such points as water pipes, for which some replacement has been necessary again in the past year. Elevators have required more than usual attention, with some fairly costly machine parts renewed. A minimum of such work is being done—it being desirable to postpone such work whenever possible, inasmuch as there are under way plans for rehabilitation or reconstruction. Another and major item facing UET, if the societies remain in the building, is a complete job of refenestration.

### OPERATING COSTS

Operating costs are largely labor costs. In a building in use from early morning until nearly midnight five days each week, and on Saturday until six o'clock, service costs, heat, light, and other essentials are necessarily higher than in commercial buildings of comparable size. To this is added the operation of meeting halls requiring cleaning, and often, rearrangement of seats between meetings, and the care of the marble corridors, lobbies, staircases—all these require special service.

The assets of the corporation, besides the value of Engineering Societies Building and its depreciation fund, consist of the corpus of gifts made to create income for certain specific purposes—to finance researches in technical subjects sponsored by the Founder Societies, or "for the advancement in any other manner of the profession of engineering and the good of mankind," or to operate Engineering Societies Library.

The quality of the UET portfolio has improved steadily, and an income of an acceptable rate for the times has been obtained.

### BUILDING DEPRECIATION RESERVE

The depreciation fund shows its importance as the enlargement of headquarters is studied, with the urgent need of ready cash. Each year $20,000 is added from building income, which with the interest from investments added $36,406.41 during the fiscal year just past, bringing its total value on September 30, 1946, to $585,721.63.

### SERVICE TO RELATED ORGANIZATIONS

The corporation holds titular ownership of the funds of the John Fritz Medal board of award, and the Daniel Guggenheim Medal board of award, managing them for these boards. It acts as treasurer for the Engineers' Council for Professional Development. It also holds in custody contributions for Engineering Foundation research projects, disbursing from them on proper authorization.

### CAPITAL FUND INVESTMENTS

The aggregate book value of capital fund investments on September 30, 1946, the close of the fiscal year, was $1,669,297.44. The market value on or about that date was $1,753,516.51 or 105 per cent of book value. The previous year showed $106^1/_2$ per cent over book value. The titular ownership of Engineering Societies Building added to these funds represents a custody of assets amounting to upwards of $3,500,000 for the engineering profession through the Founder Societies.

Through a committee, in conjunction with the Founder Societies, the matter of legal advisers has been studied and the firm of Carter, Ledyard and Milburn, New York, N. Y., has been appointed as legal counsel to the corporation, effective October 1, 1946. This firm succeeds the late Charles Adkins Baker, legal adviser to the UET since its inception in 1904.

**High-Speed Camera.** A new ultrahigh-speed camera capable of taking photographs at the rate of 200,000 frames per second was announced by the National Advisory Committee for Aeronautics. Developed for the purpose of visually slowing down the rapid combustion in an aircraft-engine cylinder for study, the new camera will take ten photographs in the space of 50 millionths of a second. This is more than sufficient to stop the motion of an object traveling at 4,760 miles per hour. The camera is of the optical compensator type, which means essentially that the photographs are taken with continuous illumination of the object, rather than with intermittent lighting by electric spark or other means. The light source is a high-intensity gas-filled tube. Using stationary film, the camera produces 204 stationary images in successive positions during the 1,000th of a second interval of one flash. The camera can be used in all kinds of high-speed air-flow investigations, such as supercharger and compressor studies where blade speed may be as high as 20,000 rpm. It also can be applied to all kinds of high-speed machinery where analysis of complicated motion is required.

**Lapps Get Electricity.** The seminomad Laplanders will be serviced with a new high-voltage power line in the province of Härjedalen, it is reported from Sweden. The line will cost approximately $280,000 and at some points will be 3,280 feet above sea level. Some of the more permanent Lapp villages received telephone service before the war. The villages usually contain tent-like dwellings of a fairly substantial yet mobile type.

**Submarine Telephone Repeater.** A submarine cable 200 nautical miles long has been laid between England and Germany since the end of the war. The longest cable of its kind, it provides one telephone circuit and six telegraph circuits over the single coaxial pair. A submerged repeater recently was included in the cable, and the number of circuits has been increased thereby to five telephone channels, any one of which may be used to provide 18 telegraph circuits. The cable is similar to the Anglo-Irish cable, except that the insulation is polythene instead of air.

**Use of Electricity Up.** Industry increased its use of electricity by 81 per cent during the defense and war period, the Federal Power Commission reported recently. However, total electric production showed a gain of only 68.2 per cent for the 1939–45 period. Sharp increases in states not heretofore considered industrial were taken as evidence of industrial decentralization. Arkansas was first with a 377.6 per cent increase in industrial use. Other big percentage

rises were manifested by Washington's 235.2, Oregon's 159.7, Alabama's 159.9, Texas' 159.7 per cent, Kentucky's 151.2, Delaware's 128.7, Louisiana's 122.2, North Dakota's 121.2, and Kansas' 115.8. The only State showing a percentage decrease was South Dakota. The commission attributed that to the wartime closing of large gold mines and processing plants.

**Strongest Plastic Developed.** Development of a plastic substance which has 30 times the impact strength of other plastics and which also is 40 per cent lighter than aluminum was reported recently by the Cornell Aeronautical Laboratory, Buffalo, N. Y. The new material is made of glass cloth dipped in plastic resins. It will be used in a dome enclosing radar equipment on an *AT-26* airplane during tests. Use of the dome is expected to increase radar efficiency about 10 per cent, as the plastic has electrical properties which reduce absorption of radar waves to 3 per cent. Earlier domes lost as much as 18 per cent of radar waves.

## New Color Television Technique Displayed

A new approach to color television reception was displayed at the Allen B. DuMont Laboratories in Passaic, N. J., on December 16, 1946. The color system, which was shown piecemeal but not demonstrated in full, was said to be adaptable to any system of color television transmission.

A single cathode-ray tube with three electron guns, one for each of the primary colors, and a special "trichromoscope" screen is the heart of the new system. The screen is composed of microscopic triangular prisms whose facets are coated with three different phosphors. The prisms all are aligned so that the similarly coated facets face the proper electron gun. In operation the basic color impulses are applied to the electron guns which direct their beams at the prism facets, and thus the basic colors are focused and merged into a color likeness of the original view.

According to the laboratory the new device will operate equally well with either of the two television systems now in operation or proposed, namely, continuous scanning or sequential scanning, or with ordinary black-and-white images.

**Food Chemists Use Electron Microscope.** A research program designed to improve taste, texture, and appearance of many familiar foods is being carried out at the General Foods Corporation laboratories in Hoboken, N. J., with the aid of an electron microscope. Through the aid of the microscope most food cells are made visible, thereby permitting study of cellular structures as they undergo processing.

## UNESCO to Have World Engineering Conference

At a recent meeting of engineers in New York it was disclosed that American participation in the World Engineering Conference of the United Nations Educational, Scientific, and Cultural Organization is being organized through the medium of the Committee on International Relations of the Engineers Joint Council. Its chairman is Malcolm Pirnie and its secretary is S. E. Reimel with headquarters in the Engineering Societies Building, 29 West 39th Street, New York 18, N. Y. A national committee is planned, with all United States engineering societies invited to be represented, as soon as formal sanction is received from the Engineers Joint Council.

Plans for the World Engineering Conference were formulated during the International Technical Conference held in Paris, France, in September 1946. At that time contact was established with UNESCO through the director of its engineering section, Doctor Yeh Chu-Pei, who emphasized the need of UNESCO for a single world organization through which it could work in bringing to the engineering profession its support and benefits.

The World Engineering Conference, which is still in provisional form, is headed by Colonel Aristide Antoine, president of the French union of engineers and technicians, who was named president of the executive board. F. B. Turck, New York consultant, has been named American representative on the board until the formal organization in the United States is completed.

**Invisible Stars Detected.** Conquest of vast regions of space previously invisible and inaccessible to the astronomers' instruments was described at the annual meeting of the American Association for the Advancement of Science held in Boston, Mass., in December 1946. This further penetration has been made possible by the use of newly developed, highly sensitive photoelectric cells, which convert light from faint stars into electric impulses. Doctor A. E. Whitford of the Washington Observatory at the University of Wisconsin, Madison, reported that a considerable region of the infrared spectrum of stars now can be studied with the aid of the lead sulphide photoconductive cell developed during the war by Doctor R. J. Cashman of Northwestern University, Evanston, Ill.

**Supercyclotron.** According to Professor E. O. Lawrence, inventor of the cyclotron, the new 4,000-ton supercyclotron just put in operation at the University of California, Berkeley, has produced a beam of deuterons carrying an energy of 200 million electron volts. This beam, first of such magnitude to be produced, was used to bombard beryllium, and an intense beam of high-energy neutrons resulted.

# EDUCATION . . .

## Training in Fundamentals Asked by Industry

Industry gives first place among the qualities it desires in young engineers to training in fundamentals, according to H. N. Muller, Jr. (M '43) of the Westinghouse Electric Corporation, East Pittsburgh, Pa., who recently described that company's training program before The American Society of Mechanical Engineers.

Knowledge of fundamentals, not only in the engineer's specialty but also in diverse subjects, is desired, Mr. Muller, who is manager of graduate student training, elucidated further. He declared that wartime experience confirmed the opinion that usually only refinements of existing processes come from specialization while more radical developments spring from fundamentals.

Mr. Muller explained that the Westinghouse Company gives all its graduate student employees an orientation course designed to give them a broad understanding of the company and its work and to discover each student's proclivities. After the orientation period all trainees undergo a basic training course which includes assignments in manufacturing, the test floor, and the laboratory and product conferences. Once the basic training is completed, students are segregated into one of three training groups: sales engineering, engineering, or manufacturing according to their demonstrated abilities and desires. The exceptional student in the engineering training group may attend an electrical or mechanical design school which carries credits toward an advanced degree. All students, especially those assigned to engineering training, are encouraged to continue with graduate work and made fully aware of opportunities for it.

**Harvard Drops Bachelors of Science.** Discontinuance of the bachelor of science degree after 1950 has been announced by Harvard College, Cambridge, Mass. First granted in 1907, the bachelor of science degree has been "the object of widespread criticism," Doctor Richard M. Gummere, chairman of the committee on admission, said in announcing the change. Doctor Gummere added that even undergraduates majoring in scientific fields "prefer to receive the arts degree."

**Teaching Safety Engineering.** A plea for the inclusion of a greater amount of safety training in college engineering courses, was made at The 67th annual conference of The American Society of Mechanical Engineers by John V. Grimaldi, research engineer, who stated that knowledge of accident prevention is as important to the engineer as basic sciences and mathematics. Refuting

the notion that safety precautions impede production, Mr. Grimaldi quoted figures from two recent surveys, one conducted by the Committee on Safety and Production of the American Engineering Council and one conducted by New York University. These bore out his contention that the safer plant is the more productive one. Mr. Grimaldi recommended that room be provided for safety training in the already crowded engineering curriculum by greater concentration on teaching the application of theory and less on the memorization of facts and formulas. He urged that the student learn to think rather than to memorize. In addition, he declared that the student would study supplementary material on accident prevention, if he were so directed and stimulated by his teachers.

**Correspondence Course in Safety.** The extension division of the University of Wisconsin, Madison, is offering a new correspondence course in industrial safety engineering directed especially toward supervisors, and others concerned with safety rules in industry. The course, consisting of 24 assignments, uses four textbooks. The fee for residents of the State of Wisconsin is $15 and for nonresidents $24. Further information about the scope of the course and enrollment procedure may be obtained from the University Extension Division, Madison, Wis.

**New Building at Michigan.** A 5-story building is being planned for the campus of Michigan State College, East Lansing, to house the electrical engineering department which at present occupies only eight classrooms and laboratories. The new building is designed, so that all the classrooms and offices and the library will be on one side of the building, while the laboratories and shops will be on the other. The top floor will be given over to club rooms and four graduate research laboratories. Included in the list of new equipment for the laboratories are an X-ray machine; the nose turret of a *B-32* bomber; a radar set; motors; generators; and radio, industrial electronic, and other electronic equipment.

**College President Elected.** Doctor B. R. Van Leer, president of the Georgia School of Technology, Atlanta, Ga., was elected president of the Division of Engineering and Land-Grant Colleges and Universities at its annual meeting held in Chicago, Ill., in December 1946.

**Collins Bliss Dies.** Doctor Collins P. Bliss, dean emeritus of the New York University college of engineering, died at Tupper Lake, N. Y., on December 17, 1946. Doctor Bliss had been associated with New York University since 1896.

## HONORS • • • • • •

**Rand Medal Awarded to Humphrey.** George M. Humphrey, president of the M. A. Hanna Coal Company, Cleveland, Ohio, and chairman of the board of the Pittsburgh Consolidated Coal Company, has been announced as the recipient of the 1947 Charles F. Rand Medal of the American Institute of Mining and Metallurgical Engineers. The award is made from time to time to recognize distinguished achievement in mining administration. Mr. Humphrey was graduated from the University of Michigan in 1912 with the degree of bachelor of laws. He joined the Hanna company as general counsel in 1918 and was elected president in 1929. He is chairman of the executive committee of the National Steel Corporation, chairman of the board of the Susquehanna Colliery Company, member of the executive committee of the National City Bank of Cleveland, director of the Phelps Dodge Corporation, and chairman of the executive committee and director of the Industrial Rayon Corporation. Mr. Humphrey was cited: "For constructive leadership in establishing great enterprises for the production of iron ore, of steel, and of coal; for signal success in the administration of large organizations engaged in these basic industries so vital to the economy of our country."

**Mathematics Prize Awarded.** Doctor Henry B. Mann, associate professor of mathematics at Ohio State University, Columbus, was awarded the Frank Nelson Cole Prize of the American Mathematical Society at a recent meeting of the society. The prize, established in 1928, is awarded each five years to a member of the society who has published the most outstanding paper on the theory of numbers. Officers for the coming year also were announced at the meeting. These are:

*President*—Professor Elinar Hille, Yale University, New Haven, Conn.

*Vice-President*—Professor P. A. Smith, Columbia University, New York, N. Y.

*Secretary*—Professor J. R. Kline, University of Pennsylvania, Philadelphia.

*Associate Secretary*—Professor T. R. Hollcraft, Wells College, Aurora, N. Y.

*Treasurer*—B. P. Gill, College of the City of New York, New York, N. Y.

**W. N. Lacey Receives Lucas Medal.** William Noble Lacey, dean of graduate studies, California Institute of Technology, Pasadena, has been awarded the Anthony F. Lucas Gold Medal for 1947 by the American Institute of Mining and Metallurgical Engineers. The Lucas Medal was established in 1936 to be awarded from time to time in recognition of "distinguished achievement in improving the technique and practice of finding and producing petroleum." Doctor Lucas has been cited for "his distinguished achievement in directing research work in the fundamentals of hydrocarbon behavior and particularly his application of these fundamentals to oil and gas reservoirs which have led to greater efficiency in oil and gas production from our oil fields. His published data have been of immense value to the petroleum industry in determining improved producing procedures for the various types of oil and gas reservoirs." Born in 1890 in San Diego, Calif., Doctor Lacey holds degrees from Stanford University and the University of California at Berkeley. He joined the staff of California Institute of Technology in 1916 as instructor. After two years of military service, he became associate professor in 1919 and was appointed professor in 1941 and dean of graduate studies in 1946.

**Mayer Award Presented.** Doctor Harlow Shapley, chairman of the National Science Fund of the National Academy of Sciences, Washington, D. C., recently announced the presentation of the $2,000 Mayer Award to Doctor C. J. Eliezer, Ceylon, India, physicist, for a paper on the nature of light. Doctor Eliezer graduated from the University of Cambridge, England, where he is a research fellow.

## INDUSTRY • • • • •

### Radio Manufacturers Form Liaison With Broadcasters

Closer co-operation on major radio problems, including development of frequency modulation, television, and other services in the public interest, is the broad objective of a joint committee just established by the Radio Manufacturers Association and the National Association of Broadcasters. The joint liaison body was appointed, respectively, by President R. C. Cosgrove of RMA and President Justin Miller of NAB, each group consisting of leaders of the respective industries.

Following is the personnel of the new manufacturing–broadcasting group:

**Radio Manufacturers Association**

W. R. G. Baker, (M'41) vice-president, General Electric Company, Syracuse, N. Y.

Walter Evans, vice-president, Westinghouse Electric Corporation, Baltimore, Md.

Frank M. Folsom, executive vice-president, RCA Victor Division, Camden, N. J.

Paul V. Galvin, president, Galvin Manufacturing Corporation, Chicago, Ill.

E. A. Nicholas, president, Farnsworth Television and Radio Corporation, Fort Wayne, Ind.

**National Association of Broadcasters**

T. A. M. Craven, vice-president, Cowles Broadcasting Company, Washington, D. C.

William Fay, vice-president, Stromberg-Carlson Company, Rochester, N. Y.

Gordon Gray, president of Station *WSJS*, Winston-Salem, N. C.

James D. Shouse, vice-president, Crosley Corporation Cincinnati, Ohio.

Carleton D. Smith, general manager, Station *WRC*, Washington, D. C.

## Wilson Sees Wage Truce as Industry's Chief Need

A respite from demands for additional wages rises is essential to a period of industrial adjustment during which the technological advances of the war can be passed on to the consumers in the form of lower prices, Charles E. Wilson, president of the General Electric Company, Schenectady, N. Y., said in a recent press conference.

During such a period, which should run at least through 1947, industry would forego price increases, Mr. Wilson declared. Lower prices are needed to expand the potential market for goods, and industry would like to dedicate itself to the task of getting prices down, he said. He ridiculed the idea that further wage increases can be paid without raising prices.

Mr. Wilson estimated that, though the General Electric Company is making every effort to absorb added costs, a 10 per cent general wage increase would mean a minimum price increase of about $7^1/_2$ per cent on its products. He said that the average weighted prices of the company have risen only 23 per cent in the face of a 50 per cent rise in wages since 1940. In an earlier interview Mr. Wilson had stated the company policy of not making any general "across the board" price increase in its products.

If industry is not given time to work back to an equilibrium where the benefits to be achieved from higher production and technical advances can be determined, Mr. Wilson foresaw the start of "another vicious spiral of inflation."

Mr. Wilson had no suggestions for amendment of the Wagner Act. He reported that labor efficiency at the General Electric plants was rising, and that the present total of 92 plants represented an addition of about 20 during the year. He announced that the company now had 160,000 employees, twice the prewar average. The order backlog was a "little less" than one billion dollars, about $2^1/_2$ times normal.

## NAM United on Labor Policy

Both the majority and minority groups of the National Association of Manufacturers are in substantial agreement on the points for new labor legislation, according to a recent statement of the minority group, after it had issued its report following the publication of the majority report adopted at the association's annual meeting held in New York, N. Y., in December 1946. Points of complete agreement are: encouragement of high wages based on high productivity and incentives for superior output, good working conditions, stabilized employment, and labor–management co-operation.

Other points for which substantial agreement was declared are: legal protection for employees in their right not to join a union; legal obligation of both union and employer to engage in collective bargaining in good faith with provision for peaceful procedures; prohibition of restraint of trade by unions as well as employers; protection of employers as well as employees in the right to express positions; extension of the protection of law to strikers only when a majority have voted a strike under an impartial secret ballot; loss of protection for jursidictional and sympathy strikes, strikes against the Government, and similar strikes; prohibition of any form of coercion or intimidation against any employee, or his family, or property to deny the right to work; no collective bargaining for foremen or other representatives of management; prohibition of closed shop or other forms of compulsory union membership; and reduction of governmental intervention in labor disputes.

**NEMA Issues Favorable Forecast.** Continued prosperity through 1947, contingent on freedom from strikes, was predicted for manufacturers of major electrical appliances in a recent statement from the National Electrical Manufacturers Association. Items particularly affected by the expanding volume of trade will be ranges, water heaters, washers, refrigerators, dishwashers, and ironers, according to NEMA. During 1947 the association is planning to seek elimination by Congress of the present excise taxes on these appliances as a preliminary to price reduction. Production during the first half of 1947 will be somewhat restricted by a shortage of steel sheets and copper. Plastics and synthetics for insulation also will be short. Many manufactures believe that a buyers' market will prevail by midsummer, but for "off brand" merchandise rather than products of established quality, it was said. It was revealed that in 1946 the appliance industry fell about one third behind its planned production schedules.

**Portal-Pay Hits Electrical Industry.** The wave of portal-pay suits filed recently, following in the wake of the United States Supreme Court decision in the Mount Clemens, Mich., pottery case tried last June, have involved many major electrical concerns, among which are: Westinghouse Electric Corporation, General Electric Company, General Motors Corporation electrical division, Western Electric Company, Sylvania Electric Products, Inc., and General Cable Company. The United States Chamber of Commerce has taken action on a proposed set of amendments to the Fair Labor Standards Act of 1938, under which the portal-pay suits fall.

**C. M. Cohn Dies.** Charles M. Cohn, chairman of the board of directors of the Consolidated Gas Electric Light and Power Company, Baltimore, Md., died December 5, 1946. Mr. Cohn was elected president and chairman of the board in 1943 and retired from the presidency in 1946. Mr. Cohn received the degree of bachelor of arts in 1897 and the degree of master of arts in 1899 from Loyola College and the degree of bachelor of laws from the University of Maryland in 1897. He entered the employ of the Consolidated company, in 1885 as a clerk. By 1906 he was secretary and in 1910 was elected vice-president and general manager and later that year vice-president in charge of the gas division. He was made a member of the executive committee in 1912 and executive vice-president in 1931. In 1942 he was appointed president of the company and in 1943 president of the board.

**Palladium for Electrical Industry.** The metal palladium has assumed an important position in the platinum industry, and the electrical industry is the largest purchaser of the metal, according to a recent report on the state of the industry by Charles Engelhard, president of Baker and Company. United States Bureau of Mines reports show that, for the first nine months of 1946, 40 per cent of all palladium sales were made to the electrical industry. The metal is used for small electrical contacts required to operate over long periods without failure. Mr. Engelhard also reported that the period of speculative trading which followed the removal of price controls is subsiding and that platinum and palladium prices are beginning to be governed by normal conditions of supply and demand.

**Silver Supply Improving.** The desire for United States dollars, and the authority given by Congress in July 1946 for the United States Treasury to sell silver at 90.5 cents per ounce to alleviate the shortage at that time, has attracted sufficient silver from the foreign market to satisfy the monthly United States industrial demand for 10 million ounces. This rate of consumption is considerably higher than that before the war, and, according to the trade, the present demand will continue throughout 1947 at least.

## RESEARCH . . . .

**Aircraft Battery Testing Laboratory.** A new laboratory for battery research has been constructed at the National Bureau of Standards, Washington, D. C., with the co-operation of the Navy Department Bureau of Aeronautics. The equipment installed provides for automatic cycling of aircraft storage batteries under conditions of room temperature, extreme heat, subzero temperature, and "flight" vibration. Present day aircraft batteries play an important part in the operation of electric equipment such as radio, radar, and lighting. They also serve as a source of stand-by power in the operation of gun turrets, bomb bays, and retractable landing gear. Because every pound added to an airplane increases the take-off distance, weight is of major concern. Hence, obtaining maxi-

mum capacity per unit weight with reasonable life expectancy is principle aim of the tests. Members of the Bureau of Standards believe that final and conclusive data from these tests will give an accurate comparison between the constant-potential and constant-current methods of charging in their effect on battery life.

## Navy Research Promises Benefit to Management and Production

The Navy's $45,000,000 basic research program should yield discoveries of immediate and practical benefit to industrial management and production, according to a recent statement of Commander Peter K. Wells of the Office of Naval Research.

In the more than 100 contracts with universities and industrial research laboratories throughout the country, four freedoms of scientific research have been emphasized, it was said. All contracts embody the following policy:

1. Freedom to initiate projects, the value of which becomes apparent to the researchers.
2. Freedom to explore new avenues as they appear.
3. Freedom to publish the findings of the research work on the premise that new knowledge of natural phenomena is inherently free.
4. Freedom to teach, so that the graduate students of a university under Navy contract, for example, may contribute to the program and that the program in turn may contribute to their education.

It was pointed out by way of example that current Navy-sponsored studies of atomic energy for driving ships and in the field of electronics would result in the expansion of commercial and industrial applications.

Rear Admiral Paul F. Lee has been chief of the Office of Naval Research since November 1, 1946.

**Microwave Spectroscope.** Radar waves from 1.2 to 1.6 centimeters in length are being used in a microwave spectroscope developed by W. E. Good, D. K. Coles, and T. W. Dakin of the Westinghouse Research Laboratories, Pittsburgh, Pa., for the analysis of chemical substances. Like the infrared spectroscope to which it is analogous, the microwave spectroscope permits identification of complicated molecules such as hydrocarbons without laborious chemical processes. In operation microwaves produced by an oscillator are directed through a wave guide which contains the sample of unknown vapor in a gas-cell section. The radiations are picked up from the end of the wave guide by a crystal detector, the output of which is applied to the vertical plates of an oscilloscope. Molecules of different substances absorb different wave lengths, thus there is a characteristic pattern of absorption lines recorded as the vertical deflection of the oscilloscope trace for each substance. Limitations of the microwave spectroscope are not known yet, but it promises to be a valuable tool in the study of molecules and even of atomic nuclei.

**$2,500,000 Sought for Research.** The Southern Research Institute, which was organized to bring the amount of that region's industrial research into better balance with the number of its wage earners and the value of its produce, has completed about 18 months of active operation and is seeking $2,500,000 as a means of expanding its facilities. Studies in progress at the institute include organic, inorganic, physical, and analytical chemistry; physics and electronics; ceramic engineering; industrial toxicology; bacteriology; agricultural and food chemistry; and biochemistry. The institute operates on a nonprofit basis with the private enterprise sponsoring each project paying its expenses. Fees from projects pay maintenance and overhead costs. The institute is governed by a board of 27 trustees headed by Thomas W. Martin of the Alabama Power Company, assisted by an advisory council of 165 members. Firms represented on the board and council subscribed most of the $1,000,000 which provided for the original plant and equipment. Doctor Wilbur A. Lazier, formerly of the du Pont experimental station at Wilmington, Del., is director of the institute.

# OTHER SOCIETIES

## Alloys of Iron Research Publishes Advances in Metallurgy

Advances in ferrous metallurgy made during the war will be recorded in a series of books to be published by the Alloys of Iron Research, a project of the Engineering Foundation, 29 West 39th Street, New York, N. Y.

The first volume, in preparation now, will contain a description of the characteristics and properties of the many new alloy steels developed during the war and a summary of new principles of plastic deformations at elevated temperatures which have proved of value in developing new steels for high and low temperature use, as in jet-propelled airplanes that operate at high altitudes where temperatures are low.

The succeeding books will be broad discussions of available published and unpublished information on individual series of new steels, and on older steels that have been improved greatly in properties in the last few years, either by the use of new alloying elements or by the use of new principles of treatment.

The Alloys of Iron Research project was re-established a few months ago after a period of inactivity during the war. It was initiated in 1930 with financial support from the foundation and from major steel producers of the country to review the important research work of the world on steel and to correlate the data thus obtained for the benefit of industries manufacturing or using steel. The results of this prewar work were published in a series of 11 monographs.

## Future Meetings of Other Societies

**American Chemical Society.** 111th national meeting, April 14–18, 1947, Atlantic City, N. J. 50th annual meeting, June 16–20, 1947, Atlantic City, N. J.

**American Institute of Mining and Metallurgical Engineers.** Annual meeting, March 17–22, 1947, New York, N. Y.

**American Society for Engineering Education.** 55th annual meeting, June 18–21, 1947, Minneapolis, Minn.

**American Society for Testing Materials.** Spring meeting and committee week, February 24–28, 1947, Philadelphia, Pa.

**American Society of Heating and Ventilating Engineers.** 53d annual meeting, January 27–30, 1947, Cleveland, Ohio.

**American Society of Mechanical Engineers.** Spring meeting, March 2–5, 1947, Tulsa, Okla.; semi-annual meeting, June 16–20, 1947, Chicago, Ill.; fall meeting, September 1–4, 1947, Salt Lake City, Utah.

**Canadian Electrical Association.** Western conference, March 3–5, 1947, Vancouver, B. C.; 57th annual convention, June 18–20, 1947, St. Andrews, N. B.

**Edison Electric Institute.** June 2–5, 1947, Atlantic City, N. J.

**Electrical Engineering Exposition.** January 27–31, 1947, New York, N. Y.

**Illuminating Engineering Society.** Southwestern regional conference, February 20–22, 1947, San Antonio, Tex.; East central regional conference, May 8–9, 1947, Washington, D. C.; Midwestern regional conference, May 15–16, 1947, Kansas City, Mo.

**Institute of Radio Engineers.** Annual meeting, March 3–7, 1947, New York, N. Y.

**Midwest Power Conference.** March 31–April 1, 1947, Chicago, Ill.

**Pacific Chemical Exposition.** October 21–28, 1947, San Francisco, Calif.

**Farm Electrification Association.** Organization of the National Farm Electrification Association has resulted from the National Farm Electrification Conference held in Chicago, Ill., in November. Officers elected for 1947 are:

*Chairman*—Hassil Schenk, president of the Indiana Farm Bureau and a director of the American Farm Bureau Federation, Indianapolis, Ind.

*Vice-Chairman*—George Kable, editor of *Electricity on the Farm*, New York, N. Y.

*Secretary-Treasurer*—Russell Gingles, manager of the Farm Electrification Bureau of the National Electrical Manufacturers Association, New York, N. Y.

At the conference it also was voted by the 400 participants to hold annual conferences. The conference recommended that the newly elected officers of the NFEA present to the Federal authorities the facts necessary to support an adequate research budget of $250,000 for the year ending June 30, 1948, for the Farm Electrification Division of the United States Department of Agriculture. A recommendation that the Edison Electric Institute provide material for 2-day in-service training schools for county extension workers was adopted. Among those attending the conference were a representative of the Soviet Government and agricultural leaders from four provinces in Canada.

## Latest ASTM Action on Standards for Materials

A number of new and revised specifications and tests recently have been approved by the American Society for Testing Materials and will be included in the 1946 "Book of ASTM Standards" now being printed. The tests and specifications also will be available in pamphlet form.

### FIRE-REFINED COPPER

The new tentative specification covering fire-refined copper for wrought alloys (*B 216*) essentially replaces the "Emergency Specification *ES-7* developed as a wartime measure and widely used to cover a large variety of applications. The types of copper covered, largely the so-called Braden type from South America, and the Morenci type from Southwestern United States, are considered quite suitable for most applications with the notable exception of uses where electric conductivity calls for a very high purity material. The permissible non-copper elements in the requirements on chemical composition for fire-refined copper are such that the material is not the best available to conduct electricity.

### ELECTRICAL INSULATING MATERIALS

The revision in the methods of sampling and testing untreated paper (*D 202*) involves the addition of a method of testing pH of paper. The method is designed to indicate the active acidity and alkalinity of aqueous extracts of electrical insulating papers. Such extracts normally are unbuffered and are affected readily by atmospheric carbon dioxide. This procedure embodies features to prevent errors from this cause. The method consists of a hot water extraction of the specimen followed by a pH measurement of the cooled extract solution in an atmosphere of nitrogen. The pH measurement involves the use of a glass-calomel electrode system with suitable potentiometric equipment.

The revision in the tests of vulcanized fiber (*D 619*) are minor, involving the incorporation of a referee test for conditioning in case of dispute. The new tentative methods of evaluating insulating oils eventually will replace the existing method *D 17*. They are based on extensive work carried out in committee *D-9* where subcommittee IV on liquid insulation has carried out a considerable amount of research, some of it involving a series of round-robin tests.

The new methods of testing askarels (*D 901-46 T*) are essentially the same as were published for information in the 1943 and 1945 reports of committee *D-9*. Requirements cover sampling, determination of various properties, such as specific gravity, color, viscosity, and dielectric strength.

### STAINLESS WELDING ELECTRODES

Developed in the joint American Welding Society—ASTM Committee on Filler Metal, the new specifications for corrosion-resistant chromium and chromium-nickel steel electrodes *A 298-46 T* have been in course of promulgation since 1940, when the subcommittee first was organized. A rather complete draft was issued about a year ago and since has been considered carefully and revised. The arrangement of the specifications and the general method of handling the requirements are patterned after the existing standard on iron and steel arc-welding electrodes, *A 233*. The test requirements set up minimum quality levels which will assure suitability for the usual applications. A guide to the specifications is appended, which is intended to aid in a proper evaluation and use of the six series which are covered.

## Agricultural Engineers Study Farm Electrical Problems

Farm equipment, design, rural electrical service facilities, and the economics of farm rates and returns to the farmers were subjects for special attention during four rural electrical sessions at the meeting of the American Society of Agricultural Engineers held in Chicago, Ill., in December 1946.

An important general conclusion from several papers and the following discussion is that single phase will be adequate for practically all requirements of farm service. A maximum motor rating of $7^1/_2$ horsepower was advocated for farm equipment, and a plea was made that electrical service companies should permit this rating on single-phase wiring. Lee Moore (F '45) principal engineer, technical standards division of the Rural Electrification Administration, opened the question of single phase.

A. E. Anderson, Commonwealth and Southern Corporation, reviewed the elements of electrical rate structures and called attention to the trend toward higher demands and lower load factors in farm use. He showed results of a 500-customer survey with 19.4 per cent annual load factor at 6-kw demand, varying approximately on a straight line to 14.1 per cent at 11 kw.

Use of electricity for farm power development will require a change in line capacities, according to D. W. Teare, United States Department of Agriculture, who presented data for estimating farm utilization and showed results in one check area with use 50 per cent greater than the most optimistic estimate of ten years ago.

**ASRE Officers Elected.** At the recent annual convention of the American Society of Refrigeration Engineers in New York, N. Y., the following officers for 1947 were announced:

*President*—Roland H. Money, Reynolds Metal Company.

*Vice-Presidents*—Clifford F. Holdke, Vilter Manufacturing Company; Burgess H. Jennings, professor of mechanical engineering, Northwestern Technological Institute.

*Treasurer*—Paul B. Christensen, chief engineer, Merchants Refrigerating Company.

# LETTERS TO THE EDITOR

**INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.**

## Sign of Reactive Power

*To the Editor:*

The sudden decision of the subcommittee of the AIEE Standards committee to change the sign of reactive power smacks of political skulduggery. Why is it necessary to try to tie in the indirection of a pure mathematical concept to the broad philosophy of power measurement? In all mathematical analysis the interpretation of results depends upon assumptions and references.

As was so ably summarized in this article, the validity of either sign is established as mathematically accurate. One depends on a voltage reference, the other on a current reference. All problems involving vectorial power can be solved and correctly interpreted by either concept. After all these years of acquiescence or indecision, why the sudden clamor to relate a mathematical concept of a vector quantity to a practical scalar quantity to which it is connected only remotely?

All the advantages on page 515, so glibly ascribed as results of this portentous decision, do not stem from such fallacious reasoning. All of these advantages have been available to system operators, rate makers, power consumers, and others for many years—in fact, ever since the wattmeter and varmeter were invented. Perhaps the subcommittee has not considered the philosophy of power measurement as an independent and primary reason for all these advantages.

The development of power measurement came from the indicating wattmeter. It is idle to detail the complete theory of this instrument. However, I would like to call to your attention that this instrument uses voltage, current, and the cosine of the included angle from

which is obtained a scalar product equal to the watts in the circuit. Moreover, this instrument in the zero center form is directional—power out may be positive, power in, negative. From the voltage and current vectors, an rms value of watts is derived which is algebraic. This conception of real power as an algebraic quantity led to the adoption of the reactive component indicator, which used quadrature voltage and the same current as the wattmeter.

This instrument, structurally, is just another wattmeter, giving an rms scalar product of voltage and current and the cosine of the included angle which, however, is the complementary angle to that of the wattmeter. Hence, it becomes the sine of the angle between the original voltage and current. Here we have two instruments which break up "apparent watts" (volt-amperes) into two complex components of real power and reactive power. These values are not vectorial but have finite values based on the unit watt, and either may have a positive or negative sign.

Unfortunately, the original reactive component indicator had the word "lag" on the zero-right scale and the word "lead" on the zero-left scale. For many years this nomenclature caused confusion in the minds of operators who lost sight of the fact that the cosine component of power and the sine component of power always have been two separate algebraic quantities. These quantities may flow independently to and from any bus in a transmission system and are controlled separately by system requirements. The use of plus and minus signs for these power components also is unfortunate as plus (out flowing) power or plus reactive (out flowing) both may be minus when flowing in to an adjacent substation bus.

When the mathematical concept now proposed for the vector of the inductive reactive power component is injected into the simple philosophy of power measurement, hopeless confusion will result and hundreds of textbooks will be outmoded.

It is a pity that our Standards committee can be stampeded into a false position by such an obviously specious argument.

G. F. SARGENT (M '40)

(Relay engineer, engineering and construction department, Tennessee Valley Authority, Chattanooga, Tenn.)

*To the Editor:*

This is written in support of the recommendation of the AIEE subcommittee regarding "The Sign of Reactive Power" in the belief that its adoption will aid in clarifying discussions of reactive power in the future.

The concept of inductive reactive power (magnetizing kilovars) as positive has been the practice of the writer's present business organization, as well as others with which he has been associated, for a number of years. As pointed out in subject report, this will continue to be the practice of many, if not all, power production and distribution organizations regardless of standard definitions.

Prior to the publication of the American Standard mentioned in subject report, insistence upon the power producers viewpoint resulted in a rather long drawn out correspondence with one instrument manufacturer who objected to the use of the designations "IN" and "OUT" instead of "LAG" and "LEAD" on the dial of a varmeter. The definition, as it now stands, tends to support this manufacturer's position and may lead to otherwise avoidable correspondence in an attempt to reach an agreement.

The advantages of the proposed concept have been so well covered in comments one through six of the report that amplification seems unnecessary.

EDWARD B. HENRY (M '44)

(Engineer, Gulf Power Company, Pensacola, Fla.)

*To the Editor:*

Referring to the AIEE committee report on "The Sign of the Reactive Power" in the November 1946 issue of *Electrical Engineering*, pages 512–16, it seems to me that, for a general clarification of the sign of reactive power, a further significant point should be taken into account in addition to those of the committee report. This is the fact whether the power in question, be it real or reactive, is delivered or received.

Real power delivered by a generator may be defined as positive. On the transmission line, the power will continue to have positive sign over its entire extension from the generator to the consumer. An unbiased consumer also will be satisfied to consider the power received as positive in this first assumption.

One and the same power flowing from the source to the user, will reverse the relative direction of flow for an observer first identifying himself with the generator and later with the consumer. Hence, it is not unjustified to attribute to the consumed power the negative sign in this second assumption. This assumption is very inconvenient for the customer who actually means to buy positive power from an electric distribution system. However, it is very convenient for the engineer since it is consistent with the working conditions of his electric machinery, which by inversion of the sign of the power change from generator behavior to motor behavior.

In actual practice, either of these assumptions is used, entirely depending upon the convenience for the user in question.

Now for reactive power, it is useful to consider separately inductive power and capacitive power, which between themselves always are identical in kind but opposite in sign and in direction of flow. If we use the first assumption, then positive inductive power delivered by the generator leads to positive inductive power received by the consumer. Conversely, transmission of capacitive power will lead to the negative sign for the power delivered as well as for the power received. As seen by diagonal comparison of the signs, however, this result is contradictory to the fact that inductive power delivered physically is identical to capacitive power received, and vice versa. Hence, the first assumption leads to results not compatible with reality.

If we use the second assumption, then positive inductive power delivered by the generator leads to negative inductive power received by the consumer. Use of the same assumption for negative capacitive power delivered leads to positive inductive power delivered. Diagonal comparison shows that inductive power delivered is identical in sign with capacitive power received, and vice versa.

In the case of reactive power, therefore, we are not free to use either assumption, as has been the case for real power. Only the latter assumption will make sense.

We see that with the co-ordination shown here a capacitor produces inductive power and consumes capacitive power, while an inductor produces capacitive power and consumes inductive power. Hence, the positive sign appears consistently as attribute of the capacitor and the negative sign as attribute of the inductor. This is in consequence of having assumed the delivery of inductive power as positive. A reversal of this association would reverse the signs.

I feel that this discussion indicates that it may not be sufficient to attribute merely a plus or minus sign to the reactive power in order to distinguish between inductive and capacitive action, but that a further statement is necessary as to whether the power is delivered or received in order to make such statement unambiguous.

REINHOLD RÜDENBERG (M '38)

(Gordon McKay professor of electrical engineering, Harvard University, Cambridge, Mass.)

*To the Editor:*

I have read with interest "The Sign of Reactive Power" appearing in the November 1946 *Electrical Engineering*. I certainly would approve the convention of considering reactive power "absorbed" by an inductive load as positive, if the power absorbed by a resistive load is taken as positive, not only for the reasons given on page 515, but also for another reason which appears to me to be even more logical, namely, that of the sign of the excitation of synchronous motors or generators, or of induction motors. If a customer is operating an induction motor, he requires both a power component and an excitation component for that motor. However, if he parallels the motor with suitable power factor correction capacitors, he not only may require no excitation from the power lines but even may supply excitation to the power system which will relieve the demand for such excitation on the power company. Similarly, if he is

operating a synchronous motor, he may control the amount of excitation exchange with the power company by varying the field rheostat of the motor. Because rates which recognize power factor usually penalize the customer if he has a lagging power factor, the customer readily can see that lagging power factor is occasioned by his excitation demand from the power system and that, if he supplies his own excitation, he makes a corresponding saving in his power bill.

You will note that I put quotation marks around absorbed as relating to an inductive load. It seems unfortunate to me that the committee report should use this word in such a sense. Personally, I would prefer to state that reactive power *associated* with an inductive load is to be considered positive.

E. D. DOYLE (F '27

(Patent engineer, Leeds and Northrup Company, Philadelphia, Pa.)

*To the Editor:*

It has been my experience both in the domestic and in the foreign field that the committee should adopt the recommended change in the sign of inductive reactive power. The reasons given in the article appearing in the November 1946 issue of *Electrical Engineering* seem to me adequate without further comments.

I believe the committee should be congratulated for agreeing to change an existing rule rather than arbitrarily trying to insist that the other rule be followed.

W. W. PARKER (M '37)

(Regional engineer, Westinghouse Electric International Company, Rio De Janeiro, Brazil)

*To the Editor:*

Being interested in the sign of reactive power from the standpoint of instruction in electric circuits, the following comments are offered only as supplementary discussion.

1. (*a*) American texts are written on the basis of counterclockwise rotation of vectors; (*b*) lagging power factor denotes current lagging voltage; and (*c*) leading power factor denotes current leading voltage, in the American system of notation and practice.

2. On the foregoing basis we rightfully teach

$$Z = R \pm jX \qquad +jX \text{ for } X = \omega L \qquad -jX \text{ for } X = \frac{1}{\omega C} \quad (1)$$

also

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \quad (2)$$

not

$$Z = \sqrt{R^2 + (X_C - X_L)^2} \quad (3)$$

3. We teach $\omega L = X_L$ to be associated in the students' minds as reactance due to magnetic field energy and $-1/(\omega C) = -X_C$ to be associated in the students' minds as reactance due to electric field energy.

4. We also teach

$$Y = \frac{1}{Z} = \frac{1}{R+jX} = \frac{R}{Z^2} - j\frac{X}{Z^2} = G - jB \quad (4)$$

Even though the sign before the $j$ quantity in the reciprocal is negative, the reactance is due to magnetic field energy. Likewise for

$$Y = \frac{1}{Z} = \frac{1}{R-jX} = G + jB \quad (5)$$

Even though the sign reverses, the reactance is due to electric field energy.

5. The signs of reactive power therefore are:

Magnetic reactive (inductive)

$$+Q = I^2(+X_L) = V^2(-B) = VI \sin \theta_{\text{lag}} \quad (6)$$

Electric reactive (capacitive)

$$-Q = I^2(-X_C) = V^2(+B) = VI \sin \theta_{\text{lead}} \quad (7)$$

6. The operation $S = VI$ is confusing to some students, because $P = VI \cos$ (angle between $V$ and $I$) and $Q = VI \sin$ (angle between $V$ and $I$) and

$$S = (V\underline{/\alpha})(I\underline{/\beta}) = VI\underline{/\alpha-\beta} = VI\underline{/-\alpha+\beta} \quad (8)$$

Either $V$ or $I$ can be conjugated. However, to keep $Q$ positive for current lagging voltage and negative for current leading voltage, $I$ must be conjugated. Thus:

$$+Q = I^2(+X_L) = V^2(-B) = VI \sin \theta_{\text{lag}} = +jQ \quad (9)$$

if $V$ ($I$ conj) is inductive reactive or magnetic field energy; and

$$-Q = I^2(-X_C) = V^2(+B) = VI \sin \theta_{\text{lead}} = -jQ \quad (10)$$

if $V$ ($I$ conj) is capacitive reactive or electric field energy.

7. Because our rotation is counterclockwise and *not* clockwise (English) and because lag or lagging in America means current lags or lagging the voltage and since lead or leading to American engineers means current leads or leading the voltage, $(+Q)$ for magnetic field reactance seems the most consistent, $(-Q)$ for electric field reactance.

A. S. BROWN (M '45)

(Assistant professor of electrical engineering, University of Arkansas, Fayetteville)

*To the Editor:*

Referring to the article "The Sign of Reactive Power" in the November 1946 issue of *Electrical Engineering*, I would like to express my hearty approval of the fact that the AIEE is tackling this problem. The usual indications in vector diagrams of reaction power and power factor often have been a source of confusion, especially with regard to such problems where electric machines alternately generate or absorb power (real and/or reactive, lagging and/or leading).

You easily can appreciate my feeling of profound respect for the Swiss author Ernst Schönholzer, who, in his book "Kurze Repetition der Elementaren und Hoheren Mathematik und Wechselstromtechnik" (Schweizer Druck-und Verlagshaus, Klausstrasse 33, Zürich 8, Switzerland), offers a solution to the problem, whereby from any given vector diagram the power flow, reactive power including its sign, phase angle, and so forth can be read unequivocally. He reaches this ideal by the introduction of the concept of "excitance," which, together with resistance, inductance, and capacitance, determine a reference system covering 360 degrees of the vector diagram. In his book, the author even suggests that his system offers itself best to international standardization, and I am, although by no means conscious of all possible and practical difficulties in the application of his system, inclined to agree with him.

May I therefore suggest that the aforementioned publication be studied seriously by the Standards committee; I hope that they will succeed in this difficult task and should feel extremely satisfied if my suggestion may have contributed to the solution of the problem.

J. F. W. VAN DER MEULEN (A '44)

(Billiton Company, The Hague, Netherlands)

## Single-Phase Induction Motor

*To the Editor:*

During the past two years a number of discussions on the theories used to explain and calculate the behavior of the single-phase induction motor have appeared in AIEE publications. The general tenor of these is to the effect that, though the two principal methods in use give accurate numerical results for performance, they

are in error or inadequate in other respects. As some of the statements printed are misleading and erroneous, an attempt to correct them should be made.

The methods in question are the double-revolving field (in either classical or symmetrical co-ordinate dress) and the cross field theories. Each of these has its sphere of usefulness, and both admittedly have certain limitations. Thus, neither is simple, and neither takes into account the disturbing effects of saturation or harmonics. The first theory easily can be made to include skin effects in the rotor, while the second in its simple vector form is blind to the existence of two frequencies in the rotor, and so forth. Now, as no simpler methods are on the horizon, we shall have to live with them for some time yet. Most of the questions at issue have been settled long ago. As many of the details may have become obscured by time, some of the alleged "defects" will be examined.

1. The revolving field theory is faulty because two oppositely revolving fluxes cannot exist in the same air gap at the same time. To "prove" it, one writer placed two equal 3-phase windings in the same stator slots and connected them in parallel, so that their fields rotated in opposite directions. When connected to the line, these windings behaved as for a short circuit. This is what would be expected. If these windings had been connected electrically in series, a non-rotating alternating field would have been obtained. Note that the experiment performed in no wise is a proof that the assumption originally made by Ferraris is invalid. This assumption was that what actually goes on in the air gap can for purposes of analysis be replaced by two fields turning in opposite directions.

2. In a letter to the editor, for January 1946,[1] and in the discussions in AIEE *Transactions*,[2,3] we read:

> . . . an assumption that has been accepted widely but on careful examination proves to be a fallacy. . . . As the stored energy of a rotating constant flux is constant, the combined stored energy of any two rotating fluxes also must be constant. Since the stored energy of a single-phase alternating flux varies twice between zero and a maximum in each cycle while the combined energy of any two rotating fluxes is constant, a single-phase alternating flux cannot be the resultant of two constant flux components as assumed in the rotary-field single-phase motor theory . . . do lead to inconsistent and incorrect conclusions.

This sounds plausible, but its implications are untrue. The two imagined components, when combined for any point at any instant, give the correct physical flux density existing at that location and time. From this, the stored energy in any element, or the entire air gap, can be found correctly. Also, if the two oppositely revolving components are equal, this field will be truly alternating in single-phase fashion, otherwise it will be elliptical, as it should be.

3. We also read:

> . . . An attempt to apply the formula developed by the cross-flux theory stating that the quadrature flux varies directly with the speed results in contradiction. Tests show that not only does the quadrature flux not increase with the speed above synchronism but that it really decreases with overspeed. Thus the straight line relation between rotor speed and quadrature flux assumed in the cross-flux theory does not exist.

Now this statement has set up a straw man and knocked him down. The literature on the subject affirms, not that the cross flux is a straight-line function of the speed in the motor as operated in practice, but that it is such a function, if, and only if, the main axis flux is kept constant.

In order to show more concretely the actual facts, Table I gives some figures from a test on a fractional-horsepower capacitor motor furnished by O. G. Coffman of the Robbins and Myers Company. These were for a 115-volt 60-cycle capacitor motor with an effective turns ratio, starting to main winding, of 1.285.

**Table I**

| Rpm | Volts Induced in Start Winding |
|---|---|
| 0 | 0 |
| 397 | 10 |
| 600 | 18 |
| 900 | 29 |
| 1,200 | 44 |
| 1,500 | 71 |
| 1,790 | 118 |

When plotted, this, of course, is not a straight line. Some figures supplied by Edward Bretch to the present writer for a 1/4-horsepower 60-cycle 115-volt 1,750-rpm capacitor motor were:

Running idle on 115 volts, 60 cycles; speed, 1,800 rpm, electromotive force induced in starting winding, 165 volts.

When directly coupled to a 3,600-rpm motor driving it at double speed, the electromotive force at the start winding was not 330 but only 10 volts. No data on the machine constants were included.

In order to get a more precise idea of the way in which the cross flux in a plain single-phase induction motor may be expected to vary with speed in a motor as operated in practice, the 220-volt motor used by H. R. West in his 1926 AIEE paper[4] was selected, and the necessary computations carried out as there outlined, over the range $S=0$ to 2. The results are given in Table II.

Here $I_1$ equals primary current from West's equation 8; $I_{2f}$ equals cross-axis rotor current in primary terms from West's equation 10.

As $S$ increases to infinity, these currents approach the values

$$I_1=\frac{E}{r_1+j\left(x_1+x_2\dfrac{X_m}{X_m+x_2}\right)}$$

$$=\frac{220}{0.12+j\left(0.4+0.4\times\dfrac{15}{15+0.4}\right)}$$

$$=\frac{220}{0.12+j0.79}$$

$$=\frac{220}{0.799}$$

$$=279$$

$$I_{2f}=I_1\frac{r_2X_m}{S(X_m+x_2)}$$

$$=0$$

respectively.

If the rotor winding were open, with a stator resistance of zero, the primary magnetizing current would be

$$I_{m0}=\frac{E}{X_m+x_1}$$

$$=\frac{220}{15+0.4}$$

$$=14.3 \text{ amperes}$$

By West's equation 19, with the rotor winding closed, the primary no load current is

$$I_0=\frac{2\times 220}{15}\times\frac{15+0.4}{15+2\times(0.4+0.4)}$$

$$=27.2 \text{ amperes}$$

This leaves $27.2-14.3=12.9$ amperes for cross magnetization at $S=1.0$. If one cares to take the trouble, the power factor, local stator impedance drop, and thence the values of the cross-axis and main-axis fluxes can be found for any speed. Their ratio is given more simply by West's equations 13 and 14:

$$\frac{\Phi_f}{\Phi_{mt}+\varphi_{2t}}=\frac{S(X_m+x_2)}{r_2+j(X_m+x_2)}\cong S$$

In conclusion, there is no indication yet that the "amortisseur theory" will be

**Table II**

| $S=\frac{\text{Rpm}}{\text{Syn}}$ | $I_1$ | $I_{2f}$ | $S=\frac{\text{Rpm}}{\text{Syn}}$ | $I_1$ | $I_{2f}$ |
|---|---|---|---|---|---|
| 0 | 247 | 0 | 0.95 | 69.4 | 12.5 |
| 0.1 | 246 | 0.47 | 0.98 | 38.0 | 13.1 |
| 0.2 | 245 | 0.97 | 1.00 | 27.3 | 12.9 |
| 0.3 | 244 | 1.53 | 1.05 | 79.0 | 13.2 |
| 0.4 | 241 | 2.19 | 1.10 | 139.0 | 13.2 |
| 0.5 | 234 | 2.98 | 1.20 | 221.0 | 11.4 |
| 0.6 | 225 | 4.02 | 1.40 | 268.0 | 7.38 |
| 0.7 | 207 | 5.37 | 1.60 | 275.0 | 5.33 |
| 0.8 | 176 | 7.5 | 1.80 | 277.0 | 4.40 |
| 0.9 | 116 | 10.5 | 2.00 | 278.0 | 3.5 |

more illuminating, more exact, easier to apply, or more comprehensive as a tool than are the older methods. In its present form, the amortisseur theory requires the interposition of graphical work, which makes it less rapid, less convenient, and in other respects not so incisive and up to date as those now in use. The latter are suitable for the slide rule, avoid the use of drawing instruments, and are (theoretically) precise in application. Finally, the figures just given are sufficient to justify the statement that the cross field, when plotted as a function of the motor speed, has the shape predicted by the theory and that this shape will not be very different from that obtained by test. The figures in Table II were obtained with a 10-inch slide rule.

REFERENCES

1. Letter to the Editor, **Edward Bretch.** *Electrical Engineering*, volume 65, January 1946, page 55.

2. Discussion by **Edward Bretch** of A Generalized Circle Diagram for a Four-Terminal Network and Its Application to the Capacitor Single-Phase Motor. AIEE *Transactions*, volume 64, 1945, page 943.

3. Discussion by **Edward Bretch** of Symmetrical Components as Applied to the Single-Phase Induction Motor. AIEE *Transactions*, volume 64, page 958.

4. The Cross-Field Theory of A-C Machines, **H. R. West.** AIEE *Transactions*, volume 45, 1926, pages 466–72.

A. F. PUCHSTEIN (M '27)

(Consulting engineer, The Jeffrey Manufacturing Company, Columbus, Ohio)

## Functional Analysis of Measurement

*To the Editor:*

The article "Functional Analysis of Measurements," which appeared in shortened form on pages 11–15 of the January 1947 issue of *Electrical Engineering*, presented a method of analysis and classification designed to provide a better understanding of measurement equipment. In developing this method, my associates and I found it essential to define carefully certain new terms on which the analysis depends and other terms often used but requiring specific definitions. Though these terms were used and described in the article, the formal definitions for them were omitted because of space limitations. Due to the increasing use of complex systems in industry for measurement purposes and also for control initiation, it is imperative that proper terms be assigned to the various functional parts and that these be defined exactly. This calls for an industry standardization; and at the suggestion of several members of the Institute I am taking this means of bringing to the attention of all those interested, the particular terms and definitions that well may be suitable for this purpose.

As explained in the article, the use of these terms and the method of analysis dependent on them has provided a clearer understanding of measurement devices and systems. Furthermore, they form the basis for an improved and more consistent "language of measurements" that is so necessary from the standpoint of application, design, analysis, research, and development applicable to this type of apparatus.

It is believed, therefore, that the formal definitions of the basic terms which were presented in the article "Functional Analysis of Measurements" and which follow as listed should receive consideration. To this end they have been submitted to the subcommittee on definitions of the instruments and measurements committee of AIEE, and they are under consideration by that group.

### NEW TERMS

*(Selected specifically for functional analysis and classification of measurements)*

**A Primary Detector is the first basic element or group of elements that responds quantitatively to the quantity measured and performs the initial measurement operation.** A primary detector performs the initial conversion or control of measurement energy and does not include transformers, amplifiers, shunts, resistors, and so forth, when these are used as auxiliary means.

**An End Device is the assembly of basic elements that responds quantitatively to the quantity measured and performs the final measurement operation.** An end device performs the final conversion of measurement energy to an indication, record, or the initiation of control.

**The Intermediate Means includes all basic elements that are used to perform necessary and distinct operations in the measurement sequence between the primary detector and the end device.** The intermediate means, where necessary, adapts the operational results of the primary detector to the input requirements of the end device.

**A Measurement Component is a general term applied to parts or subassemblies that are used primarily for the construction of measurement apparatus.** It is used to denote those parts made or selected specifically for measurement purposes and does not include standard screws, nuts, insulated wire, or other standard materials.

**A Basic Element is a measurement component or group of components that performs one necessary and distinct function in a sequence of measurement operations.** Basic elements are single-purpose units and provide the smallest steps into which the measurement sequence can be classified conveniently.

**An Auxiliary Means is a basic element or group of elements which changes the magnitude but not the nature of the quantity being measured to make it more suitable for the primary detector.** In a sequence of measurement operations it usually is placed ahead of the primary detector.

**Control Initiation is the function introduced into a measurement sequence for the purpose of regulating any subsequent control operations in relation to the quantity measured.** The basic element or group of elements comprising the control initiator usually are included in the end device but may be associated with the primary detector or the intermediate means.

### EXISTING TERMS

*(Specifically defined for use in functional analysis and classification of measurements)*

**A Measurement Device is an assembly of one or more basic elements with other components and necessary parts to form a separate, self-contained unit for performing one or more measurement operations.** It includes the protecting, supporting, and connecting as well as the functioning parts, all of which are necessary to fulfill the application requirements of the device.

It should be noted that end devices, as defined under "New Terms," frequently but not always, are complete measurement devices in themselves, as they often are built in with all, or part, of the intermediate means or primary detectors to form separate, self-contained units.

**A Measurement System consists of one or more measurement devices and any necessary auxiliary or intermediate means interconnected to perform a complete measurement from the first operation to the end result.** A measurement system can be divided into general functional groupings, each of which consists of one or more specific functional steps or basic elements.

**Measurement Energy is the energy required to operate a measurement device or system.** Measurement energy can be obtained either from the quantity being measured, from an external source, or from both.

**Measurement Equipment is a general term applied to any assemblage of measurement components, devices, apparatus, or systems.**

**A Measurement Mechanism is an assembly of basic elements and immediate supporting parts for performing a mechanical operation in the sequence of measurement.** For example, it may be a group of components required to effect the proper motion of an indicating or recording means and does not include such parts as bases, covers, scales, and accessories. It also may be applied to a specific group of elements by substituting a suitable qualifying term; such as, "time-switch mechanism" or "chart-drive mechanism."

I. F. KINNARD (F '43)

(Works engineer, West Lynn (Mass.) works, General Electric Company)

## Evaluating Military Engineering Experience

*To the Editor:*

There seems to be a tendency on the part of some employers in the engineering field to place ex-soldiers in responsible positions in the mistaken belief that the technical experience some of them might have acquired while serving in the Armed

Forces during the war would be of great value.

It is, of course, proper to accord them preferential treatment, but only up to a point. It should be remembered that such experience is of a kind that hardly recommends itself for general use, inasmuch as things, due to abnormal circumstances and military necessity, are in wartime done in a slipshod rather than an efficient engineering way. To this should be added that in many instances the prewar experience of those men has been rather limited, many are still very young and therefore do not possess the maturity that good engineering demands.

It is, therefore, a slap in the face of all those who are older and of greater experience to place such inexperienced and young fellows in supervisory positions, and it is also an insult to the whole engineering profession, inasmuch as it has a tendency to lower the quality of engineering service—it's like putting the cart before the horse. It can not be denied that it is an exceedingly bad practice to reach into the kindergarten when choosing engineering and drafting supervisors.

OLOV E. ANDERSON (A '31)
(Detroit, Mich.)

## Reorganizing the AIEE With Other Organizations

*To the Editor:*

I submit the accompanying copies of my recent exchange of correspondence with Secretary Henline, believing that the letters deal with matters of broad interest and significance to our whole membership:

"*Dear Mr. Henline:*

Just a few lines to let you know we had the pleasure last evening, November 21, of hearing from the AIEE Vice-President of District 4, Mr. H. B. Wolf (F '45) of Charlotte, N. C., at a dinner talk in the El Comodoro Hotel, at a meeting of the Miami Subsection, Fla., and we had 61 present.

Mr. Wolf gave us a fine talk on the merger of the various engineering organizations. They passed out a questionaire to us, and I am sending mine to C. H. Summers (M '38) secretary–treasurer of the Florida Section, with my comments, some of which I am writing herein as my reaction and wish to have a reply on your opinion at your convenience. It is possible I may have the wrong slant on this, but I believe I have it fairly well established in my mind.

First, I am not at all in favor of changing the name of the AIEE. The AIEE is now some 62 years old. It has served us well, so why not let it go on and retain its identity, memberships, grades, and so forth.

If we were to reorganize into a new organization, with, for example, the civil engineers, mechanical engineers, mining engineers, and others, making it a 'big four,' all under the one and same organization name, we stand to lose our identity and seniority, and to become just one small fellow in a big crowd, and our problems would not be common with the other branches of the organization.

It may mean a reclassification among our members, by this I mean some are Associates, some Members, some Fellows—now if we merge with the other organizations or engineering societies and become one organization, we, in all probability, would have to be reclassified and take examinations to qualify for the grade in question. Many of the older members would not care to do that, would feel they might have to step down to a lower classification, and in all probability would resign from the organization in which they have held membership and which they have cherished for years.

We do not want to be 'lost in the crowd.' We are a self-supporting organization. If we seem to be operating at a loss due to increased financial obligations, then let us raise the dues $5 per member, and I am sure no one would have any objection to that. I would pay $25 a year before I would lose my grade in the AIEE or forfeit my membership.

To the foregoing suggestion of affiliation with the other engineering societies and changing the name of the AIEE, I am opposed 100 per cent. Why should we lose our diplomas, membership badges, identity, seniority, and so forth just to become affiliated with a large group which has very little in common with us, as we are 100 per cent electrical men; and the other organizations would feel likewise. I see no real benefit in the proposed plans of *A*, *B*, *C*, or *D*. I do see a benefit along the following lines.

Let us create a central body known as 'The American Engineering Council.' This council would be composed of the entire organizations of the AIEE, American Society of Mechanical Engineers, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, and others. Let this council be our fighting body to battle out problems that we feel we cannot handle, but let us retain our present AIEE organization 100 per cent. The council would have officers selected from the officers of the AIEE, the ASME, the ASCE, the AIME, and others to form an executive council, which in turn would battle for any one of the societies involved in a problem was mutual to all.

Let us retain the present Associates, Members, Fellows, diplomas, seniority, and identity which in no way impairs our standing or affiliation with other organizations but lets us recognize the other Societies and lend all possible assistance to them at all times.

This American Engineering Council would be composed of the AIEE, the ASME, the ASCE, the AIME, and any other eligible organization. The engineering council could take from us problems in which we need its support. In that way we have the strength and backing of the aforementioned organizations.

At this time we are looked upon as the highest electrical authority in the United States and abroad. We plan the standards that the manufacturers follow in building machinery, distribution equipment, and so forth, and are recognized as the key authority in the electrical field. Let us keep it that way. If we get into too big a crowd, with too many other organizations, we become lost in the crowd and lose our identity and accomplishments.

I say let us keep the AIEE as it is, but let us form an American Engineering Council composed of the big engineering societies. Let us retain the management and operation of our own organization and retain present grades of Associate, Member, and Fellow and let each present member retain his identity and seniority and grade of membership. May I have your reaction to my suggestions?

Sincerely yours,
F. W. KNOEPPEL

*Dear Mr. Knoeppel:*

I appreciate sincerely your letter of November 22d, and am in complete agreement with all of your statements.

The objectives of the Institute are primarily technical. As you stated, the Institute should retain its identity, and continue its regular work. The provisions for handling technical subjects have not kept pace with the developments in electrical engineering. For the leadership which the Institute should exert in technical developments, more flexibility and speed are absolutely essential.

In the discussions sponsored by the committee on planning and co-ordination, general organization matters have overshadowed greatly procedures in the technical work.

Having heard the discussions at about six conferences arranged for the presentation of the material of the committee on planning and co-ordination, I am sure many of the discussers had only a vague idea of the problems that would be met in any of the four plans. For instance, collective bargaining has been mentioned frequently as a field in which engineering societies should be active, and some one of the plans was chosen because it seemed to meet the needs from this viewpoint. As a matter of fact, no organization including both employers and employees can take an active part in collective bargaining. If this fact had been faced squarely, the selection of plans by many individuals would have been changed.

There has been much confusion also from disregarding completely the vast differences between engineering and medicine, and choosing plan *D* because it is similar to the American Medical Association. This choice is weakened further by the facts that there are some 75 other national medical societies, and the dental organizations are entirely separate from the medical. While these facts sometimes are mentioned, they largely are ignored by many engineers who think the only need is to follow the medical profession.

One frequently hears statements that engineers are ineffective in broader mat-

ters merely because there is no over-all organization of engineers. It is more accurate to say that there is no such organization for the reason that engineers hold such widely different views on nontechnical subjects that there is no possibility of unified action. Many of these matters involve commercial and political aspects to such an extent that no engineering organization could accomplish much in them, because few engineers are experts in those fields. Thus, much of the present unrest among engineers is due to yearnings regarding which no organization of engineers could accomplish much.

The assumption that a single engineering society with 100,000 or more members could carry on all technical work and also be effective in legislation, collective bargaining, and many other broad activities, with very modest dues, is attractive to many. However, long experience in the joint activities of the engineering societies has convinced me beyond any doubt that the usual lack of agreement on nontechnical subjects and the efforts always made by some to cover broader fields than specified in the statement of objectives make such a plan wholly impracticable.

In my opinion, engineers are losing heavily through efforts to make engineering a strictly defined profession. It is a profession only under a very broad definition of "profession," as the person-to-person service, which is characteristic of professions, is almost entirely absent, and a great many engineers are employees of large organizations. The public would understand engineers much better and regard them as having a higher place in our civilization, if the engineers themselves would be thoroughly honest and describe engineering as what it actually is—practical applications of sciences and economics in a great diversity of types of work, ranging from highly technical research, development, or design to business management.

But this is too commonplace for some engineers. They must use the high-sounding, but greatly overworked, term "profession". Then they think they must modify the whole existing setup of engineering societies, regardless of the technical work, to support the desire for a definite profession and to establish a vaguely defined unity in nontechnical matters, so that certain individuals who think they are experts in some of the nontechnical fields can make a show of having the support of all engineers. These procedures never will raise the prestige of engineers.

There is a great and increasing need for revised statements of objectives of engineering societies. In recent years, various problems with which engineers have been confronted have drawn some of the societies farther and farther into fields that can be considered within the province of engineering societies only under the assumption that such societies should be active and effective in everything affecting the welfare of their members. This, if carried to logical limits, would encompass legislation, compensation, working conditions, medical services, food, housing, and practically all matters connected with satisfactory living conditions. We are facing a real question as to "what should be the objectives of an engineering society?"

There is strong support for a national engineering council based upon local councils. At present, about 45 Sections of the Institute are active in such local councils. The American Engineering Council (1920–1940) failed because of lack of agreement among the member groups regarding the objectives. The local engineering councils eventually should supply grass-roots representation, and provide a sound foundation for a national council. This is, however, likely to be a rather slow process. There can be no quick and sound solution.

These and other related matters are of fundamental concern to the Institute and to the engineering profession. Your further comments are invited.

Sincerely yours,

H. H. HENLINE

(Secretary, AIEE)"

My heart is in the AIEE, and I am going to do my part in preserving the organization that has stood as an outstanding technical organization, leading the electrical industry for the past 62 years.

F. W. KNOEPPEL (M '44)

(Electrical engineer, United States Naval Air Station, Richmond, Fla.)

## Reorientation Needed on Engineering Curricula

*To the Editor:*

In 1904 there was a professor in one of the outstanding German engineering colleges who lectured on "Old Applications of Electricity." He had been teaching for about 50 years, which places the start of his teaching career back in 1854, just a few years after the first telegraph line was built. There was at the time no Maxwell and no Hertz. There was no telephone, no generator, and no motor. The professor then was considered one of the world's outstanding authorities on the practical applications of electricity which consisted of wet cells, telegraphy, perhaps electric bells, and a few other items. The title of his course was then "Practical Applications of Electricity," and students flocked to his lectures from all over the world. Time marched on and he continued with the same lectures. About 1900 someone called his attention to the great electrical industry that had grown up and the outstanding department of electrical engineering in his own school. So, he changed the title of his course to "Old Applications of Electricity" and continued with the same lectures.

Probably we have no such drastic foolishness in American engineering schools today. But we have traditional systems of teaching that are utterly antiquated. Because historically the d-c machine existed before the a-c machine, and because the textbooks on d-c machines existed first, many schools still take up an enormous amount of the student's time teaching d-c machines before they teach anything about alternating current, even though there is no such thing as a real d-c machine in industry and no student possibly can understand what goes on in the winding of a so-called d-c machine without understanding a-c circuits. It would be more logical, much easier, and more interesting to the student, if, after having been instructed in the problem of induction, he was taught first the transformer and then the induction motor, followed by the a-c generator. Finally all he would need to study to become familiar with what are termed d-c machines would be the problem of commutation. Most professors with whom the subject was discussed agreed that this would be logical. The only argument they offered against it was that the textbooks would have to be rewritten. Are curricula to be determined by the mere existence of textbooks, no matter how antiquated they may be? Should not textbooks be written to meet educational requirements instead of vice versa?

A similar situation prevails in the teaching of chemistry. First the student is taught inorganic chemistry, mostly a matter of memorizing with an utter lack of systematic reasoning. Then comes organic chemistry with more systematic reasoning, but with memorizing still dominant. After all this hard work is finished, the student is taught the whole science over again, in a simple, systematic manner, by the use of the electron. Why not start right out with the electron? It would be easier to teach, easier for the student to understand, more stimulating to the creative mind, and more interesting. Here again we are told that textbooks first would have to be rewritten.

Why teach trigonometry before teaching calculus? Trigonometry is difficult to understand, in fact impossible of complete understanding, without calculus. With a knowledge of calculus, trigonometry becomes easy. But again, the textbook would have to be rewritten.

How many more items of this kind are there in the engineering curriculum, to burden the young mind with unnecessary memorizing, frequently making for a loss of interest in a very interesting subject? A complete survey no doubt would reveal many such antiquated procedures. The good professor does not permit his course to be governed by the mere existence of antiquated textbooks. He knows that no textbook is ever up to date, particularly in electrical engineering. The professor must be ahead of the textbook, as the engineer must be ahead even of published articles. What the engineer does today may not appear in a magazine for two years and may not penetrate the textbook for ten years.

Many, if not most, industrial developments took place backward historically. Does this mean that we must teach them backwards?

At this particular time, when so many young men have returned from the armed services, after having been forced to delay

graduation for two or three or four years, it is important to make sure that they are not burdened with utterly unnecessary, uninteresting, and uncreative work.

For the same reason it is of some importance to analyze the old discussion which recently has been repeated in connection with veterans: What should an engineering education be? Three classes of opinion can be crystallized:

1. The universalist's conception of engineering education.

2. The specialist's conception of engineering education.

3. The fundamentalist's conception of engineering education.

### THE UNIVERSALIST'S CONCEPTION OF ENGINEERING EDUCATION

Under this heading must be included all those who recently appeared on the scene to advocate that it is not enough for an engineer to be a good engineer; that he must also be a high-class economist, a sociologist, a psychologist, an expert in political economy, and many other things. It is difficult to understand why the members of these various professions expect an engineer to be an expert in their own fields. If engineers could be experts in all these fields, there would be no need for all the other professions. Of course, an engineer's human interest in economics, sociology, political economy, philosophy, and other fields is no different from what his interest in music would be. It can be only a hobby to him and a source of recreation, not a profession. An engineer should have a general cultural background, but he cannot be a jack-of-all-trades. It is hard enough to be a good engineer even in one specific branch of electrical, mechanical, or civil engineering. It may be worth mentioning that it would be well for economists, sociologists, and the others, also to stick to their lasts and not to attempt to tell the engineer how to do his engineering.

### THE SPECIALIST'S CONCEPTION OF ENGINEERING EDUCATION

This thought emanates mostly from a minority group of manufacturing and operating establishments who expect the schools to deliver to them a finished product who is ready to produce and earn full salary, possibly produce the value of several times that salary on the first day he enters employment. They feel that an engineer in school should be trained in the use of their specific catalogues, he should be familiar with all their manufacturing methods, and bookkeeping methods, and so on. They claim that if the schools do not deliver them a finished product of that nature, the schools are not competent. It is not necessary to discuss this subject at length. Even trade schools do not produce complete mechanics.

### THE FUNDAMENTALIST'S CONCEPTION OF ENGINEERING EDUCATION

Experience shows that a young engineer who has made the fundamentals of physics and mathematics a part of himself, who has engineering in his blood, will not find it difficult, in a very short time, to become a specialist in almost any branch of engineering. No engineer knows when he graduates what specialty he may run into. Those who are already specialists when they graduate will find it difficult to secure a job under normal conditions. But those who know their fundamentals can jump into almost any job and in a very short time acquire the experience they need.

It is particularly important for those who lost several years of their career in the armed services, to acquire a thorough knowledge of the fundamentals of mathematics, physics, and engineering in a modern way. As to practical experience, they can acquire more in one month on a job than in several semesters in school.

Another question which has been rediscussed recently is what kind of experience a graduate engineer should try to acquire immediately upon graduation. The following suggestions are presented, not necessarily, but possibly, in the order of their importance:

1. *Drafting.* An engineer who never has worked on the drawing board remains a cripple for the rest of his life. School drafting is utterly inadequate. Drafting should be superimposed on computations, making it possible for the graduate to apply immediately his knowledge of fundamentals acquired in college. To show the importance of design experience it is only necessary to mention that AIEE, for instance, in the qualifications for higher rank of membership, specifically mentions designing. Drafting experience does not mean drafting radio diagrams. It means the kind of drafting which will make it possible for the young engineer to visualize three-dimensional space.

2. *Testing in an Industrial Establishment.* This will give the young engineer the "feel" of equipment and instruments, a practical conception of the degrees of accuracy required for different purposes and an instinct for safety. This work also should be superimposed on computation, for the same reason.

3. *Operation.* This is particularly important for the electrical engineer. Operating work will force him to acquire a visualization of a power system from the boiler to the load. The best experience in this field probably would be load dispatching or inductive co-ordination testing.

4. *Construction.* A great amount of engineering is done in the field, and no one can acquire this experience unless he has been in the field.

Any engineering graduate who acquires in school a thorough knowledge of fundamentals and then a year or two of experience in any two of these four activities will not find it difficult to adjust himself to any engineering responsibility which may be placed upon him later. He will know definitely the difference between what he knows and what he does not know, and the difference between what he understands and what he can do himself.

M. M. SAMUELS (F '24)

(Special engineering consultant to the administrator, Rural Electrification Administration, Washington 25, D. C.)

## NEW BOOKS ...

**"National Fire Codes, volume V, National Electric Code" (ASA C1—1946).** This edition, which supersedes the edition of 1940, was adopted at the 1946 annual meeting of the National Fire Protection Association and approved as an American Standard on October 4, 1946. The provisions of this code constitute a minimum standard for the practical safeguarding against electrical hazards. Compliance with the code will insure reasonable freedom from accident, but not necessarily efficient or convenient service. It has proved itself to be the "safety blueprint" for the electrical industry. Presented for the first time in conveniently bound desk reference size, uniform with the other four volumes of the National Fire Codes, the 1947 code contains examples, an index of all NFPA publications relating to various sections of the code, and an advertising section of "approved" products. National Fire Protection Association, 60 Batterymarch Street, Boston 10, Mass., 1947, 408 pages, $6^1/_2$ by $9^1/_2$ inches, $2.00.

**"A Bibliography of Statistical Quality Control."** This annotated bibliography is intended as a manual for beginners as well as veteran industrial quality-control engineers and teachers. Approximately 340 authors are represented in the 712 articles, manuals, and books taken from 137 different periodicals which were published in the United States, England, Canada, and Australia. The bibliography is divided into three parts: articles; manuals, monographs, and pamphlets; and books. The articles are listed chronologically under the periodical in which they appeared. The period 1924–45 is covered. For reference to publications by known authors, a cross reference list of authors is provided. By Grant I. Butterbaugh. University of Washington Press, Seattle, Wash., 1946, 114 pages, paper bound, 6 by 9 inches, $1.50.

**The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.**

MANUAL OF OPERATION FOR THE AUTOMATIC SEQUENCE CONTROLLED CALCULATOR. (Annals of the Computation Laboratory of Harvard University, volume 1.) By the Staff of the Computation Laboratory with a foreword by J. B. Conant. Harvard University Press, Cambridge, Mass.; Geoffrey Cumberlege, Oxford University Press, London, England, 1946. 561 pages, illustrated 11 by 8 inches, cloth, $10. A historical introduction surveys the development of mechanical aids to calculation from the days of the abacus to the present. It is followed by a description of the calculator; by chapters on the general principles of its operation–its electric circuits, coding, plugging instructions, and the solution of examples; and by detailed appendixes on the methods of operation of the calculator's various parts. Not designed for a specific purpose, this gen-

eralized machine performs a wide variety of computations useful in all scientific fields. A bibliography and an index are included.

INDUSTRIAL ELECTRIC HEATING AND ELECTRICAL FURNACES. By E. S. Lincoln. Essential Books, Duell, Sloan and Pearce, New York, N. Y., 1945. 192 pages, illustrated, $8^1/_4$ by $5^1/_4$ inches, cloth, $3. The three principles of electric heating—resistance, infrared, and induction—are discussed, with detailed descriptions of the equipment by which they are put to practical use. Electric steam boilers, electric ovens and dryers, and electric furnaces are dealt with particularly, including discussion of efficiencies and the calculation of heating requirements. Space is devoted to the selection and installation of heating units.

INDEX OF MATHEMATICAL TABLES. By A. Fletcher, J. C. P. Miller, and L. Rosenhead. McGraw-Hill Book Company, New York, N. Y.; Scientific Computing Service Limited, 23 Bedford Square, London W. C. 1, England, 1946. 450 pages, illustrated, $9^1/_2$ by 6 inches, cloth, $16. This valuable compilation provides a complete index to all published and some unpublished mathematical tables both in books and in magazines. Part I consists of 24 sections, each devoted to tables of a particular group of functions: logarithms, natural functions, exponential functions, Bessel functions, and so forth. The tables generally are listed in decreasing order of the number of decimals. Part I contains a listing of the references to tables arranged alphabetically by authors and chronologically under each author. The user refers from part I to part II for the complete reference.

HUMAN FACTORS IN MANAGEMENT. Edited by S. D. Hoslett. Park College Press, Parkville, Mo., 1946. 322 pages, 9 by 6 inches, cloth, $4. This collection of reprinted articles by authorities brings together some 18 discussions of various phases of the problem. Broadly classified, they deal with the nature and conditions of leadership, leader or foreman training, worker reactions, and adjustments through the counseling method. A group of four special articles presents the viewpoints of a psychologist, an anthropologist, and a sociologist, with regard to the whole field, and a systematic treatment of the general question of morale.

HEAVISIDE'S ELECTRIC CIRCUIT THEORY. By H. J. Josephs with foreword by W. G. Radley, Chemical Publishing Company, New York, N. Y., 1946. 115 pages, diagrams, 7 by $4^1/_4$ inches, cloth, $2.25. The author bases electric circuit theory on a theorem, reconstructed from the scattered papers of Heaviside, from which the Carson integral equation may be derived. Beginning with a chapter on fundamentals of electric circuit theory, the author discusses the expansion theorem and Heaviside's "last theorem" and their relation to ladder networks and transmission lines, and devotes the final chapter to the application of modern theories of integration to the solution of circuit problems.

GERMAN-ENGLISH SCIENCE DICTIONARY. By L. De Vries. Second edition, revised and enlarged. McGraw-Hill Book Company, New York, N. Y., and London, England, 1946. 558 pages, $7^1/_4$ by 5 inches, cloth, $4.50. This useful volume has been revised and enlarged with a particularly substantial increase in the number of terms relating to biology, agriculture, and forestry. Many more idioms and abbreviations have been included, and the practical value of the book has been increased by an appendix containing geographic names, a conversion table, and various symbols and measurements.

GEOMETRY OF ENGINEERING DRAWING. By G. J. Hood. Third edition. McGraw-Hill Book Company, New York, N. Y., and London, England, 1946. 362 pages, illustrated, $9^1/_4$ by 6 inches, cloth, $2.75. This text utilizes a direct method of teaching descriptive geometry, adopting the procedures, vocabulary, and point of view of the engineer when he visualizes and designs structures. In this third edition a new chapter on views and their relations has been added. Increased space is given to methods for determining the intersections and developments for various combinations of plane and curved surfaces. Applications to aircraft design are given. All of the 900 problems are new.

ELECTRONIC ENGINEERING MASTER INDEX. January 1935 to June 1945. Edited by F. A. Petraglia. Macmillan Company, New York, N. Y., 1946. 209 pages, $10^1/_4$ by $6^3/_4$ inches, cloth, $6. This volume contains Part II of the Electronic Engineering Master Index published in 1945, and covers the period from 1935 to 1945. It is a classified listing of articles from 65 magazines, including all technical articles from the strictly electronic publications and selected articles from other technical periodicals. A cross index of subjects is appended. There is as yet no author index.

ELECTRICAL ENGINEERING. By E. E. Kimberly. Second edition. International Textbook Company, Scranton, Pa., 1946. 407 pages, illustrated $9^1/_4$ by 6 inches, cloth, $3.50. Written specifically for the engineering students not majoring in electrical engineering, this text is designed to enable them to deal understandingly with electrical problems and electrical engineers, and to select electric power equipment intelligently. It covers, in a functional manner, electrical and magnetic theory, electric circuits and machinery, both alternating and direct current, batteries, transformers, illumination, electric heating, and electronic devices. Consideration also is given to the economics of the use of electric apparatus.

APPLIED ELASTICITY. By J. Prescott. Dover Publications, New York, N. Y., 1946. 666 pages, illustrated, $8^3/_4$ by $5^1/_2$ inches, cloth, $3.95. Written from the viewpoint of the engineer rather than the mathematician, the mathematical theory is carried out only so far as is necessary for its application to practical problems. General stress-strain relations are dealt with first, followed by a number of chapters on thin rods, thin plates, and cylinders under various conditions of pressure and strain. Separate chapters are devoted to the vibrations of rotating disks and to elastic bodies in contact.

SWITCHBOARDS AND PANELBOARDS. By E. S. Lincoln. Essential Books, Duell, Sloan, and Pearce, New York, N. Y., 1945. 150 pages, illustrated $8^1/_4$ by $5^1/_4$ inches, cloth, $3. All phases of the construction, operation, and maintenance of switchboards and panelboards are covered, including metal-enclosed, truck, demountable-withdrawal, and rigid types of switchgear. A special section is devoted to the uses and methods of installation of panelboards which employ fuses or circuit breakers. Definitions and rating standards are given for power switching equipment.

SOUTHERN HORIZONS. By W. Haynes. D. Van Nostrand Company, Inc., New York, N. Y., 1946. 316 pages, $8^1/_4$ by $5^1/_2$ inches, cloth, $2.75. This book describes the resources of the southern United States from Texas to the Atlantic, shows what is being done by modern methods in the line of development of new products, and actively advocates the further extension of power sources to effect a general development of the results of current research.

MODERN ORGANIC FINISHES. By R. H. Wampler. Chemical Publishing Company, Brooklyn, N. Y., 1946. 452 pages, illustrated, $8^1/_2$ by $5^1/_2$ inches, cloth, $8.50. This book is primarily a book of methods. Descriptions of modern finishing materials and equipment for their application, drying, and conveying are presented, with emphasis on the proper selection and proper use of materials and equipment to get the best possible finish at minimum cost. Enamels, lacquers, varnishes, stains, and "synthetics" mainly are considered, with little consideration given to oil-base paints.

INDUSTRIAL ELECTRIC CONTROL. By E. S. Lincoln. Essential Books, Duell, Sloan and Pearce, New York, N. Y., 1945. 374 pages, illustrated, $8^1/_4$ by $5^1/_4$ inches, cloth, $3. This book provides a manual for the study of the control equipment by means of which the basic voltage of all electric apparatus is regulated. The fundamentals of control by resistance, reactance, switching, and electronic means are described in a simple, straightforward manner. Following the description of equipment available, examples are given for the use of each device in different processes. Over 200 diagrams and photographs are used to illustrate the text material.

HIGHER MATHEMATICS. By J. W. Mellor Dover Publications, New York, N. Y., 1946. 641 pages, illustrated, $8^3/_4$ by $5^1/_2$ inches, cloth, $4.50. Mathematical concepts and methods are introduced and discussed in close connection with the manipulation of the results of physical or chemical observations. The mathematical fields dealt with are as follows: calculus, analytical geometry, infinite series, differential equations, Fourier's theorem, probability and the theory of errors, calculus of variations, determinants, certain special functions, and the solving of numerical equations.

TRANSFORMATEURS INDUSTRIELS. By M. Lapiné. Dunod, Paris, France, 1946. 139 pages, illustrated, 10 by $6^1/_2$ inches, paper, 330 francs. This practical book describes a variety of tests for industrial transformers. Among the topics covered are windings, losses in a vacuum, short circuit, insulation, overheating, coils, connections, and defects resulting from accidents. The final chapter discusses the operation of transformers in parallel. Instrument transformers are not considered.

PROTECTIVE AND DECORATIVE COATINGS. Volume 5, Analysis and Testing Methods. Edited by J. J. Mattiello. John Wiley and Sons, New York N. Y.; Chapman and Hall, London, England, 1946. 662 pages, illustrated, $9^1/_4$ by $5^3/_4$ inches, cloth $7. The fifth in a series, this book considers the industry's problems in analysis and testing. The five sections are by various authorities in the respective fields: 1. "The analysis of resins" describes current procedures and methods, such as radiography, X-ray diffraction, and ultraviolet, and shows how the physiochemical properties of resins are employed for analytical purposes; 2. "The chemical analysis of drying oils" is presented as a routine analysis as well as a means of identification; 3. "Laboratory testing of metal finishes" is covered thoroughly; 4. The determination of the "spectral characteristics of pigments in the visual and infrared bands" by spectrophotometric and photographic methods is described; 5. "Resinography," the graphic study of resins and plastics, is developed as analogous to metallography in the study of metals.

# PAMPHLETS . . .

**The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.**

**The Use of Research by Professional Associations in Determining Program and Policy.** By E. L. Brown. Russell Sage Foundation, 130 East 22 Street, New York, N. Y., 1946, 39 pages.

**Specifications and Tests for Electrodeposited Metallic Coatings.** American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 46 pages. Lots up to 9, 25 cents per copy; 10 to 24, 20 cents per copy; 25 to 99, $17^1/_2$ cents per copy.

**Symposium on Materials for Gas Turbines.** American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 200 pages, $3.

**Tin and Its Uses.** Number 17, October 1946. This publication is being issued at irregular intervals at the present time by the Tin Research Institute, Fraser Road, Greenford, Middlesex, England. The United States representatives of the institute are: Battelle Memorial Institute, 505 King Avenue, Columbus, Ohio. No charge, 14 pages.

**Proceedings of the Third New England Traffic Engineering Conference.** National Conservation Bureau, 60 John Street, New York 7, N. Y., 64 pages.